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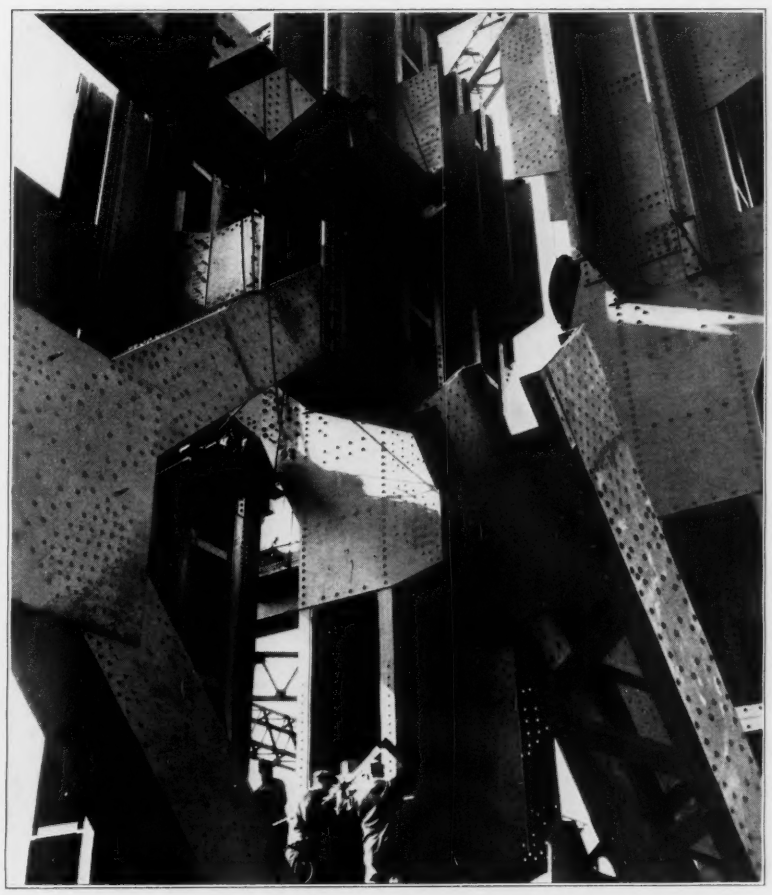

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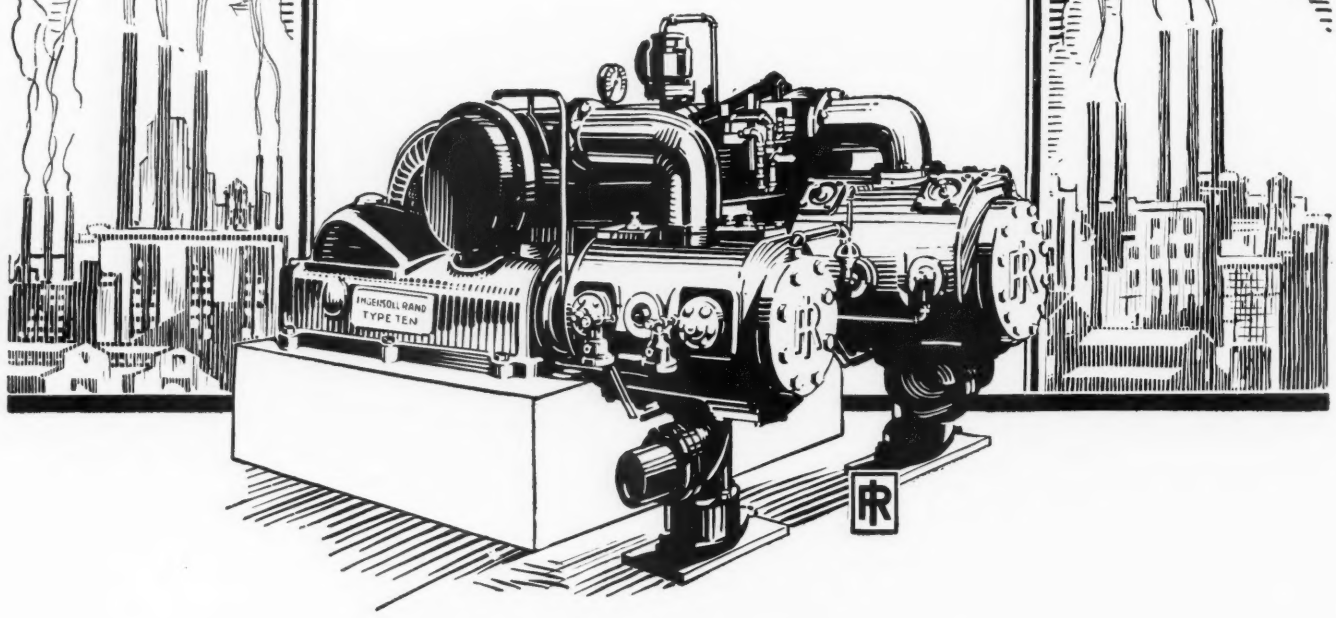

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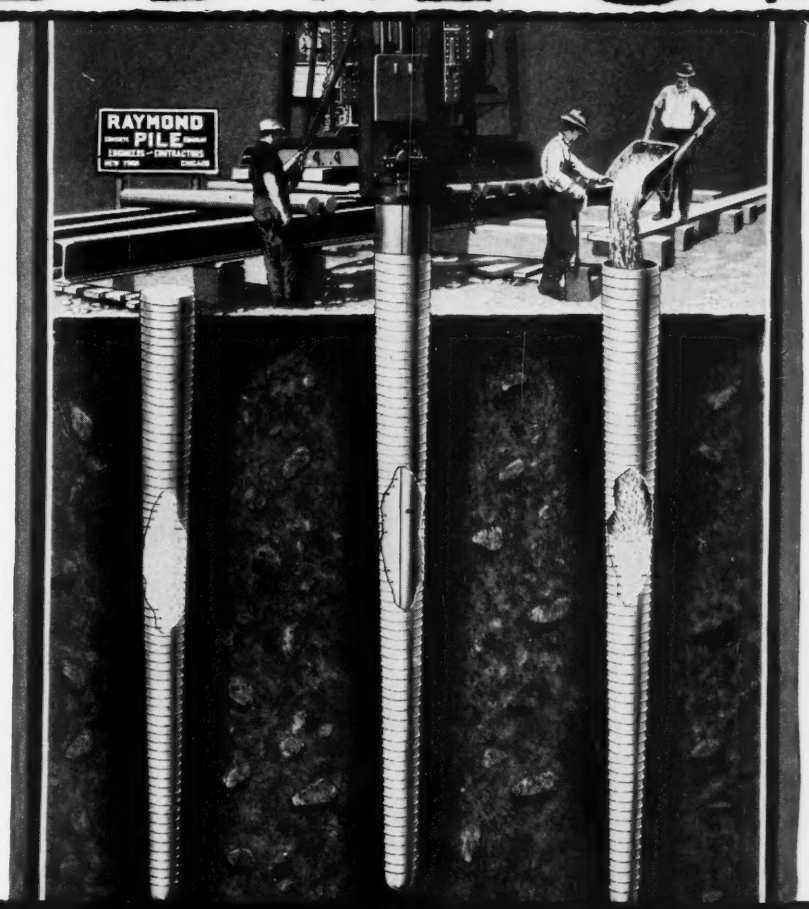

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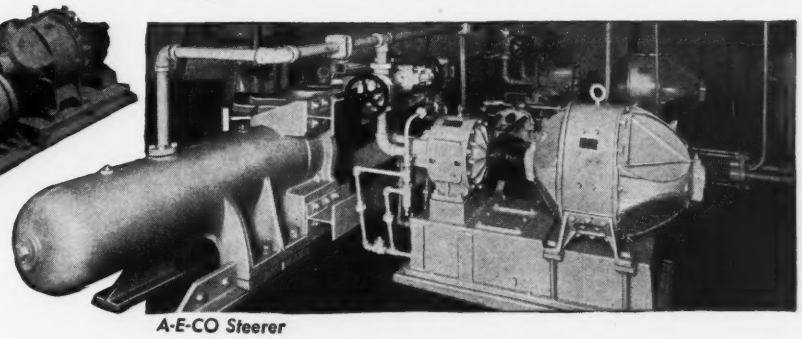

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President
Massachusetts Institute of Technology

IT is a privilege to welcome the appearance of the new volume of THE TECH ENGINEERING NEWS and at the same time to express my belief in its value to undergraduates, alumni, and all others who are interested in the varied aspects of engineering progress. This value arises not only in the information contained in its interesting articles, but even more in the stimulation and breadth of view which come with contacts outside our immediate work, yet still so closely associated with it as to give it life, background and perspective. May THE TECH ENGINEERING NEWS have a good year!

DR. COMPTON.

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XI | OCTOBER, 1930 | NUMBER 5

Reflections of An Engineering Experience

BY MAJOR WILLIAM C. GOTSHALL

YOU, Gentlemen, are now on the threshold of practising the engineering sciences, and I shall try to give you some of the results of my observations in this field. To my mind Science is the beacon and pilot of mankind and of civilization. If reverence is due to anything or to any of our fellows, it is to Science and its interpreters and developers. The great dynamic forces of civilization are the pure and applied sciences, and their interpreters are the research workers and engineers.

It seemed to me that one of the most apt of the Aldred addresses was that of Mr. Nickerson. Between every two lines of that lecture I read two other lines. It is a most remarkable exposition of an unconquerable spirit and of the outcome of persistent, purposeful hard work; and the man stands out as a personified spirit of "Never Say Die." He kept right on taking them on the point of the chin, going down, getting right up again and coming back for more, until he finally whipped that ubiquitous opponent whom we all encounter and know by many names of "Opposition," "Discouragement," "Can't-be-done." I advise you all to read that lecture.

You have courses in technical subjects administered by acknowledged authorities, and I shall not try to add anything to their teaching. I can speak of what I've seen during an active career of some thirty-five years — of some of the things a successful engineer should put into his Education and of some that he should put into his Practice.

To me a most remarkable attribute of engineering is its romance. Explorers of distant lands are sometimes regarded with an admiration approaching awe. Many people thrill at seeing a picture of a man or woman, rifle in hand, standing over a fallen animal. Killing most of these animals is just about as dangerous and exciting as killing a barnyard cow. I know whereof I speak for I hunted big game for many years and one day was much surprised when that true scientist, Carl Akeley, told me that he understood that he and I were heroes and asked me if I had heard about it yet. There is not an animal in the world that stands a chance against a high-power rifle in the hands of a man who knows how to use it. The thrills in stalking and killing wild animals are generally those of mediocre mentalities and do not last long. The stalking of wild animals to study their habits is, of course, quite another and most commendable activity.

The greatest explorers and pathfinders of all times have been and are now the engineers and research men, without whose preliminary activities and findings and developed instruments, our explorers of seas and deserts could not move. There are no greater thrills in the realms of human activity than those experienced in the various fields of Science and Engineering, and every accomplishment in these fields is gained by assiduous stalking. Often do I envy the geologist, who is a trained scout, following obscure trails toward the earth's history, or the archaeologist stalking his rare but most eloquent relics on the very shores of human origin. And the engineer, like the scientist, is a stalker ever pursuing and bringing to humanity some useful prize.

Is there any greater epic in the history of big-game hunting than the story of Mr. Washington A. Roebling and the erection of the first great suspension bridge? He risked life and health — almost lost both — did lose his health, and directed much of the work from his bed. He died in 1926 honored and revered by all. Like Shakespeare, his work is his monument. Every suspension bridge since is built on the principles of Mr. Roebling's Brooklyn Bridge. They are now stringing the wires for the cables of the new Hudson River Bridge at 178th Street, New York City. It gives me a thrill every time I pass it and see the little carriers stringing the wires. I know that Mr. Ammann, the chief engineer, would be glad to have any of you come and see the whole process, and it is well worth while.

Kit Carson and Daniel Boone were pioneers and pathfinders; but Newton, Darwin, and the long roll of men whose names I read upon the stones of your Institute, were not less truly pioneers and explorers in dark places. Was there ever a more remarkable instance of pathfinding than the mathematics of Adams and Leverrier pointing the way to Neptune? As for real danger, is there anything more dangerous or thrilling than the life of the microbe-hunter, ever seeking to conquer disease, or than that of the atom-explorer? Some day one of these tireless scientific hunters will startle the world with the demonstrable assertion that he has captured the knowledge of the transmutation of bases. It's an interesting speculation to try to picture the resulting economic and industrial conditions in the event of such a contingency; and the picture doesn't lack a humorous side.

As you pursue your studies, looking forward to a

career, we senior engineers are looking back upon many active years; and part of the purpose of the Aldred Lectures is for us to exchange views across the intervening time. What do we *retain* of all that you are now learning? How much of it served us, and how can you turn our experience to use? You are entering fields of scientific activity requiring specialized lines of thought and specialized modes of expression, for both of which there is the required language — and that language is Mathematics.

Science is organized knowledge, and organization is the *sine qua non* of any successful career. There is no royal road to Science but its confines, once entered, are ever-increasing sources of delight and success; and as Doctor Michelsen recently said: "Science is lots of fun." So I counsel you to court science and learn to speak fluently its language — Mathematics. It is true that discoveries are occasionally made and devices brought out by men devoid of such knowledge, but these are relatively rare exceptions.

Major William C. Gotshall, of the Engineer Reserve Corps, has had wide experience in the engineering field. Electrical expert and chief engineer of many commercial projects, he is responsible for the three-wire system in electric railways, and for the conversion of the Second Avenue Horse Car Railway in New York to the underground electric conduit type. He has seen active service in the World War, and has won many medals in military service. A big game hunter, a collector of paintings and first editions of books, Major Gotshall numbers among his achievements considerable experience in archeological research. He is at present engaged in the design and development of new railways and the purchase of existing roads for rehabilitation in America, Europe, Africa and the East.

We hear much of the "self-made man," who proclaims that he has no need of Mathematics. Just what does he mean by success? Does he mean mere money? If that is all he means, his life is not very full. To be sure, sufficient money to obviate a struggle for existence is necessary, but that, and much more, is always at hand for the successful scientist and engineer. I have known a number of such so-called successful men and have rarely seen a contented one. They generally have no mental foundations of culture, and without them life is empty. Such men cannot participate in a scientific conference even relating to their own immediate activities. They can but lean on their better-trained colleagues, the scientist and the engineer. Many self-made men have great personal force, boundless energy, and large common sense. The reward of their vision, leadership, and hard work is often large in money; but, though they strode to success untrammeled by knowledge, their career does not teach us that knowledge is useless, or that you and I can become engineers without Mathematics.

Unfortunately, but few engineers are really good mathematicians, but those few are the outstanding giants of the profession. It is frequently the mathematician who sees and knows things years before their practical application or appreciation. Have your Mathematics in fully workable condition, at least through integral and differential calculus, not merely so that you can work out textbook problems, but so that it can be used readily in the problems presented by research experiment and by practical construction. Your Mathematics should be a carefully developed instrument which you should be able to adroitly and skillfully wield toward a desired end.

Let us consider Physics. As your professional activities and contacts are essentially material, it is well to have your Physics thoroughly in hand so that you may have an analytical insight into the physical relations involved in engineering problems. Be guided by a deep conviction that nothing is really true which is not physically true. All constructions improve as we learn how to find and measure the physical constants on which our engineering constructions depend. More and more we find that the old "Factors-of-safety" — which were really measures of our ignorance of Physics — are being replaced by quantitative physical knowledge.

It is largely because of our increasing knowledge of Physics that each year the engineer dares more greatly in construction, performing feats which were thought beyond the bounds of possibility a short time before. Faults in engineering work are generally due to imperfect analysis of the physical conditions involved. These two trainings — Mathematics and Physics — are to be unforgettable. They should be learned so that you will be able to think freely in terms of them. Specialized training in your chosen branch of engineering should follow and build upon these fundamental sciences.

Simple as this sequence is, it is often forgotten by all except the most serious students. It is a common failing to hope that we shall get through our "Grind" at Mathematics and Physics when we enter actual construction — save, of course, for a few formulae. This is not true; the real engineer is he who has made the two great fundamentals as much a part of his mind as the language he speaks. For the past ten years American engineers have been recognized and sought for all over the world. Real success in foreign countries demands a knowledge of the language of that country, and I call your attention to the importance of a fair knowledge of four or five languages such as German, French, Italian, and Spanish. One great coming field for the engineer is certainly South America.

Another important instrument of success is to develop the art of speaking in public and to learn to think on your feet. Nowadays engineers are constantly called upon to address public bodies such as common councils, boards of aldermen, various commissions and corporation boards of directors. Very often the lawyers like to get the data from the engineer and do the addressing. But why such second-hand and, generally, incomplete and inefficient presentation of your ideas and results? Do it yourself. This faculty is one which must be developed, but it is easy to do. I shall not offer you the pebbles of Demosthenes; but to begin with, read good, well-written literature and note carefully the different modes of expression. Acquire a full vocabulary and practise clarity, facility, and brevity of expression. Above all, know all and everything about the subject you are going to talk about if you would inspire confidence in yourself. A clear exposition gives you a large handicap over your opponents. To use the words of St. Paul, "Speak with authority." Don't try to pass the buck. You will never have the confidence of your clients or of the public if you don't show confidence in yourself.

Men are always sensitive about any reference to their personal appearance, and most of us feel that we know all we need to know about it. But the engineer has a peculiar problem. He must rough it like any other good workman, in the field and even in the laboratory; and he often feels an excuse for looking rougher than a doctor or a lawyer looks. Even in the field a man may wear clothes designed for the field, which look purposeful and correct, just as a dinner jacket looks at home after six; and the laboratory too has its livery,

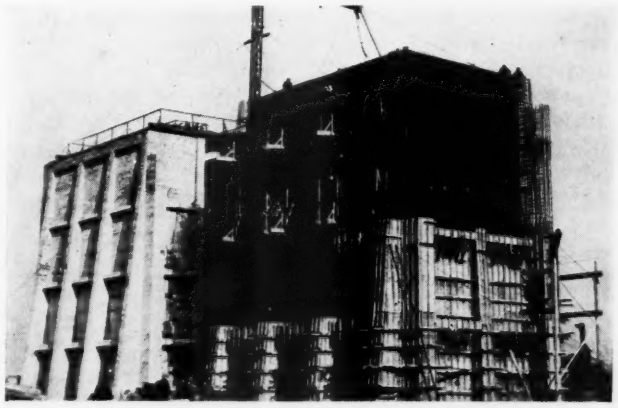
(*Continued on page 198*)

Hydrogenation of Petroleum Oils

BY THEODORE A. MANGELSDORF '26
Assistant Professor of Fuel and Gas Engineering, Massachusetts Institute of Technology

SOME two decades ago Friedrich Bergius, in Germany, began his researches on the chemical nature of coal. These resulted in developments that may in the course of a few years revolutionize the entire process of petroleum refining. It was in 1913, three years after starting his investigation, that Bergius discovered the possibility of liquifying coal by the direct addition of hydrogen under the action of heat and pressure. So interesting was this discovery, and so important, that it led to an extended investigation which culminated in the erection by the I. G. Farbenindustrie of a full scale coal hydrogenation plant at Leuna, near Merseburg, Germany. The purpose of this plant is to produce gasoline, which Germany lacks, from coal, which it has in abundance. While the operating difficulties have not yet been entirely eliminated, it has been demonstrated that coal may be effectually liquified by hydrogenation, thus settling the question of an adequate supply of liquid hydrocarbons for hundreds of years to come. It has been aptly stated that the world's coal reserves have become the world's oil reserves.

In the United States, however, the liquefaction of coal is of little immediate importance. With strenuous efforts being made to curtail the present overproduction of petroleum it would be folly to further increase the supply by the liquefaction of coal. But if by the hydrogenation process it is possible to convert coal into gasoline, then it should also be possible by the same process

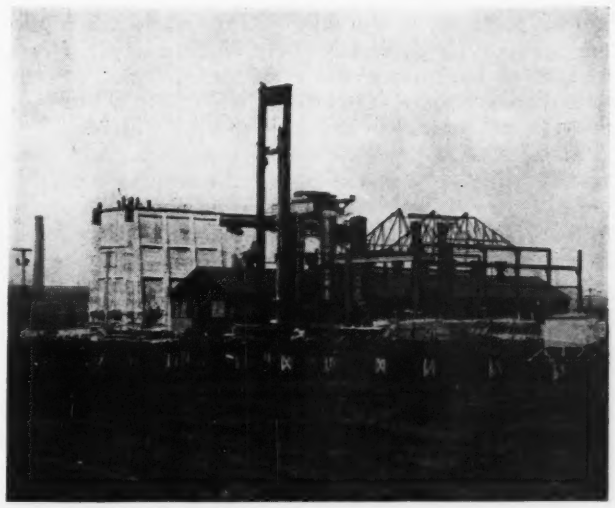


Concrete "stalls" enclosing the reaction chambers in which the hydrogenation takes place. This photograph was taken prior to their completion, and show the intricate methods of reinforcement.

to convert heavy petroleum crude oils and residues into gasoline. With this in mind the Standard Oil Company of New Jersey entered into a patent and development agreement in 1927 with the I. G. Farbenindustrie, covering new methods for the production and refining of oil products by hydrogenation. An extensive program of research and development was immediately begun. After several years of laboratory and semi-commercial development a 5000-barrel per day "Hydro" plant was built at Bayway, New Jersey, which was placed in operation during the past month, and two more units of the same size are under erection in other refineries.

In principle, the plants for the hydrogenation of oil are the same as for the treatment of coal but with some differences in details of construction. In both cases the coal or oil, and hydrogen, together with a catalyst are subjected to pressures up to 3,500 pounds per square inch and to temperatures up to 1,000° Fahrenheit for a period of time sufficient for the reactions to take place, the process being continuous.

The development of the process to its present stage is an engineering achievement of considerable magnitude and one in which Technology graduates have



The new 5,000 barrel per day Hydrogenation plant recently placed in operation at Bayway, New Jersey.

played no small part. Not only was it necessary to study the reactions in the laboratory in order to determine the optimum conditions of temperature and pressure and to find a catalyst capable of producing the reactions desired, but it was also necessary to evolve methods for the production of catalysts and hydrogen in commercial quantities and at reasonable prices. The high temperatures and pressures used in the process necessitated extensive investigations into the properties of alloy steels to be used in the equipment. Other problems too numerous to mention arose in the course of the investigation, and each had to be solved and was solved before it was possible to proceed with the erection of full-scale plants.

It is difficult to estimate the effect which this process may have on the future of oil refining. It is certain, however, that it will help to solve some of the major problems now confronting the petroleum industry. The research work has shown that it is possible to convert heavy asphaltic crude oils, high sulfur crudes, or refinery residues, into non-asphaltic low sulfur distillates with yields of practically 100 per cent. That is, from 100 barrels of heavy fuel oil which is at the present time a drug on the market, there may be produced by the Hydro process, 100 barrels of high quality gasoline requiring little if any further treatment.

The importance of this will be realized when one considers the quality of crude oils now available as compared with the quality of those which could be had in the earlier days of the industry. The first crudes pro-

(*Continued on page 208*)

Two-Way Television

BY BION H. FRANCIS '29
Member of Bureau of Publications, Bell Telephone Laboratories

THE girl at the desk picked up her phone.

"Mr. Francis to see Mr. Hanscom."

A moment later she turned to me and indicated the door ahead.

"In there, please. Mr. Hanscom will see you immediately."

So far there was nothing to distinguish the scene from a thousand similar ones enacted in business offices every day throughout the country: but ——

I stepped into a small, dimly lit room, sat down in a chair, and swung around facing a large white square in the end wall. In the middle of this was a black rectangle, in which glowed a circle of blue light. Below this spot of blue, my eye was attracted by an inscription set in a square of white light. I bent closer and read "Ikonophone — watch this space for image."

There was a slight click, the inscription vanished, and the white light of the square dimmed to a pinkish hue, in the center of which Hanscom's face looked out at me. "Hell, Francis, ——," and we launched into our discussion as if we were separated by only a few feet instead of by two miles of New York skyscrapers.

Although this sounds like A.D. 2000, it is an account of an event which happened on April 9, 1930; for on this date, Bell Telephone Laboratories demonstrated the latest advance in television — a two-way channel which had been set up between the Laboratories and the new building of the A. T. & T., two miles away.

The two-way television differs very little fundamentally from the system used in the original demonstration. It consists essentially of two complete systems, set up in the buildings mentioned above. In each building is a scanning disk and a bank of photoelectric cells for transmitting the image, and a disk and neon lamp for receiving the image. The scanning disk, which serves to direct the beam from an arc lamp on the party, is about 21 inches in diameter; placed above and to the sides of the party are 12 photoelectric cells, which pick up the reflected light and generated the television signals. A neon lamp is exposed to the party through a magnifying lens by means of the holes of a disk placed below the scanning disk. The neon lamp is of course actuated by the signals generated at the other end.

The light that plays over the face of the party is necessarily brilliant. If the light from the arc were used directly, not only would the effect be unpleasant, but the eyes, dazzled somewhat by the intensity of it, would find the neon image rather hard to see. By a fortunate chance — of which at times there seem to be few in the engineering world — the light which is least offensive to the eye is most effective in the operation of the photoelectric cell. This light lies in the blue; consequently a blue filter is used in front of the arc. The result is inoffensive.

That intensity in the scanning beam is desirable is strikingly evident when one realizes that the current generated in the photoelectric cell is of the order of a ten-thousand-millionth ampere. The neon lamp which gives rise to the image must have a current fed to it of the order of one-tenth ampere. There is then a thousand-million fold increase in current to be effected between the sending and receiving apparatus.

For the transmission of the images between the two stations, the appropriate stages of the amplifier system are coupled by special transformers, to telephone cable circuits specially designed to transmit without distortion the extremely complex current variations.

Throughout the whole system, great care is taken to present a perfect image to the observer. In the latest apparatus, the number of holes in the scanning disks has been increased from fifty to seventy-two. Although this increases the difficulty of transmission, since frequencies in a range of from 10 to 40,000 cycles are used (ordinary telephone circuits carrying a range of about 2500 cycles), the image is very clear and distinct.

On July 2, it was demonstrated that lip-reading can be performed satisfactorily by viewing the television images. Two persons with impaired hearing carried on a conversation with the speed of an ordinary telephone conversation, and met with the success usually attending this type of communication.

Inasmuch as the common telephone set masks the face somewhat, it was felt desirable to eliminate this. Accordingly, a microphone and loud speaker have replaced the common set. The parties are thus able to converse as if face to face. The best type of instruments available have been used, in order to keep distortion at a minimum. The microphone is of the condenser type, widely used in radio broadcasting and sound picture work. They are small, and so can be concealed near the

(*Continued on page 208*)

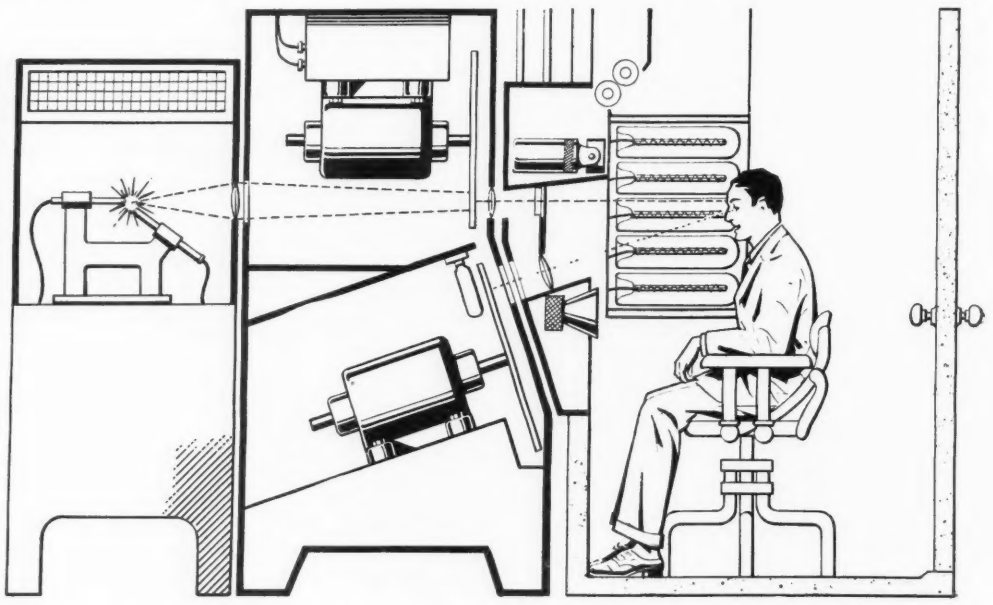


Diagram of television apparatus. Note that a microphone and a loud speaker are used in place of the ordinary handset, so that the face is not obscured.

The Road to Success

BY CHARLES R. GOW

Former Professor of Humanics, Massachusetts Institute of Technology; Postmaster, Boston Postal District

THE primary function of the modern college is to develop leaders whether it be leaders of thought or of action. The amazing complexities of our present-day life are constantly demanding an ever-increasing number of individuals who are capable of directing the forces of nature and coördinating the activities of those about them, to the end that the needs and desires of mankind may be satisfied. There is no scarcity of opportunity for the exercise of the talents of leadership. The deficiency occurs in the supply of competent and energetic men and women capable of assuming the direction of our coöperative efforts.

To those who qualify for the task, there await the honors and emoluments of life. If the individual is not to lead, he must be satisfied to follow with the great competitive mass of fellow men who occupy a like position in society.

The college classroom cannot be expected automatically to inculcate the qualities of leadership to the student. It can at the best only supply the tools or facilities which, intelligently and understandingly applied to the problems of life, may be expected ultimately to produce leadership. The college may confidently be relied upon to do its full part, but the finished product will always depend upon the coöperation and self-discipline of the individual. A college degree in and of itself is of no especial value unless it is accompanied by certain complimentary qualities which can only be developed by the student himself. It is merely an evidence that its owner has demonstrated an ability to acquire knowledge. It does not guarantee that he is competent to apply that knowledge in a useful manner.

The present generation of successful business leaders is composed in large measure of non-college men. They succeeded in reaching conspicuous places in spite of their lack of educational advantages because they possessed in great degree the self-developed qualities referred to. Undoubtedly their value to society would have been much enhanced had they in addition possessed the knowledge and mind training which the college now supplies. In any event, it is now apparent that future leaders will be recruited almost exclusively from among college-trained men.

A few years ago, Dr. C. R. Mann of the Carnegie Foundation conducted a survey for that body to determine the essential factors which were required to make a successful engineer. The opinions of some 1500 of the country's leading engineers were obtained and when combined in composite form they indicated that of 100% of necessary qualifications only 13% of the total pertained to technical knowledge. The balance of 87% was made up of such elements as character, which accounted for 41%; judgment, 17.5%; efficiency, 14.5% and knowledge of men, 14%.

These last items of necessary equipment for success cannot be supplied by the college even though it be granted that a proper educational training may aid in stressing their importance and in affording some opportunities for their exercise. Their full acquirement will depend upon the intensity of effort which the student himself exerts during the period of his college career in an endeavor to perfect himself in these departments.

Character, in addition to the customary moral requirements, will include such attributes as perseverance, self-reliance, courage, industriousness, diligence, self-control, courtesy, punctuality, application and many other qualities of a similar nature.

Judgment presupposes the ability to make correct decisions in advance of the event and can be developed only by practice and experience. Good judgment, however, requires an extended knowledge of many things; of economics, politics, business conditions and trends, finance, history and, above all else, of human nature and human beings.

Efficiency implies accuracy, methodical habits, thoroughness, patience and various other similar qualities.

Knowledge of men; of the vagaries of dispositions; of the psychology of human minds; of emotions; mental reactions, both stimulants and depressants; of human feelings and aspirations; and of all related phenomena are of prime importance to one who is to be charged with the direction of the work and efforts of groups of employees. Without such equipment, the individual is seriously handicapped in attempts to secure coöperation from others.

It is undoubtedly true that education in such matters as those described must come largely as a result of experiences and observations in direct contact with the actual problems of business and of life. It would be a mistake, however, to assume that no opportunity is afforded the student during his college career to acquire a valuable training along these lines.

Many of the attributes of character may be developed out of associations formed through relations with fellow students, as well as with the college staff. The wise selection of friends and intimates will frequently stimulate character by the power of example. The counsel of sympathetic instructors, if heeded, will do much to aid in the formation of desirable traits. The student who honestly desires to improve himself in this regard will never lack opportunity to progress.

Nor will there be any difficulty in finding occasions for the exercise of sound judgment. True, the problems presented may be of minor consequence, but they will be important from the standpoint of training. Decisions must be made daily, relative to many requirements; the selection of subjects, the choice of diversions, the appropriate disposition of economic questions and a miscellaneous assortment of incidental questions which are bound to arise.

Assuming a full appreciation of the value of good judgment, the wise student will accustom himself to read regularly the daily papers and become familiar with the tides and currents of life, not only in his own surroundings, but as well in the far corners of the world. He will devote a fair share of his leisure hours also to reading works on history, autobiographies and political discussions. He will avail himself of occasional opportunities to attend lectures and debates upon various subjects of current interest. All of these practices will serve to broaden his horizon and improve his understanding of the relations of causes and effects.

Efficiency may easily be applied in connection with the daily routine of college life. The student should carefully plan his work, his play and his entertainment. It is easily possible to develop in advance a complete schedule of the week's activities; the hours for classwork, for study, for exercise, for reading and for amuse-

(*Continued on page 196*)

Construction Features of

BY MONTGOMERY B. CASE

Engineer of Construction, The Port of New York Authority

THE bridging of the Hudson between Fort Washington, New York City, and Fort Lee, New Jersey, involves the construction of the longest single span suspension bridge in the world. Unprecedented increases in traffic volume between these two states have made the undertaking of this huge engineering project imperative, but the problem of financing and constructing such a structure was a very difficult one. The Port of New York Authority, established by compact between New York and New Jersey in 1921, has undertaken to finance the work by issuing bonds in its own name, together with temporary aid rendered by the two states, and to construct the bridge as part of an extensive plan of interstate crossings. The income to be derived from the operation of the bridge will provide security for these bonds, and all funds loaned by the states will be repaid in full with interest, so that there is no tax cost involved.

The problem of location, type, and size of the structure was a comparatively simple one. The extreme length made simplicity of design essential, and the crossing between Fort Washington and Fort Lee was almost ideally suited to the suspension type of bridge. In addition, the architectural features of a suspension span make it a fitting companion for the massive Palisades.

The suspension bridge is the simplest type of long span structure, and as such involves certain definite features of design. Such a bridge consists, essentially, of two steel towers which support heavy wire cables. These cables are fastened at either end in masonry or rock anchorages. From the cables is supported the floor of the bridge by means of vertical suspension ropes. At each end, the bridge floor meets the approaches which connect it with the existing traffic arteries.

Construction Details

The construction of the bridge was started in the spring of 1927, with the tower foundation on the New Jersey side. Two large cofferdams were sunk through the bed of the river to the solid sandstone below. The silt overlying the rock was dredged out and the wooden framework of the foundation floated on the surface. This framework was then sunk, a section at a time, until the entire frame was in place, the lowest section near the bed rock and the highest just above the water surface. Steel sheeting was then used to enclose the framework bracing, and the steel box thus formed was pumped out by electrically-driven pumps. The remaining silt and loose rock was then removed, and as the foundation bed was uncovered, concrete was poured in, a layer at a time, until the entire volume was filled. When completed, the tower foundation consisted of two huge mass-concrete blocks, 100 feet square in area, and from five to 15 feet above the water surface. The foundation on the New York side, built on a rocky promontory of Manhattan schist, is of similar design, but much shallower, since the bedrock is above the surface of the river. Work on the foundations was completed late in June 1928, and the construction of both towers was under way on July 1.

During the construction of the tower foundations, rock was being excavated from the Palisades to allow for the anchorage steel and masonry, and to form an approach to the bridge floor through the rock wall. This excavation consists of two separate cuts, an approach cut 146 feet wide and 750 feet long extending 50 feet below the top of the Palisades, and an anchorage cut below the approach level. So extensive is the work that the contractor has installed a complete rock-crushing plant at the field, and is selling crushed trap rock to a concrete aggregate dealer. The New Jersey anchorage tunnel extends through the rock wall downward at an angle of about 45 degrees. The excavation was accomplished by sinking a shaft from the top of the Palisades to a point corresponding to the lowest point of the anchorage tunnel, and by blasting outward and upward through the rock wall. All rock from the anchorage tunnels was removed through the original shaft. The result was a complete lack of interference between the two blasting operations, and a considerable saving in time. The New Jersey anchorage was completed by setting large steel girders and eyebars, to which the cable wire was to be fastened in the tunnel, and fully embedding these in concrete masonry.

On the New York side, no natural anchorage was at hand, so a gigantic masonry block, 130 feet high, and rested on bedrock, was constructed. Conveyor belts were used to carry the concrete to the distributing tower with such efficiency that 90,000 cubic yards were laid in four months, corresponding to a block the size of a small house put in place every day. The anchorage steel was set in place on steel supports and buried as the concreting proceeded. By May 1929, all of the necessary work on both anchorages preliminary to cable building was complete.

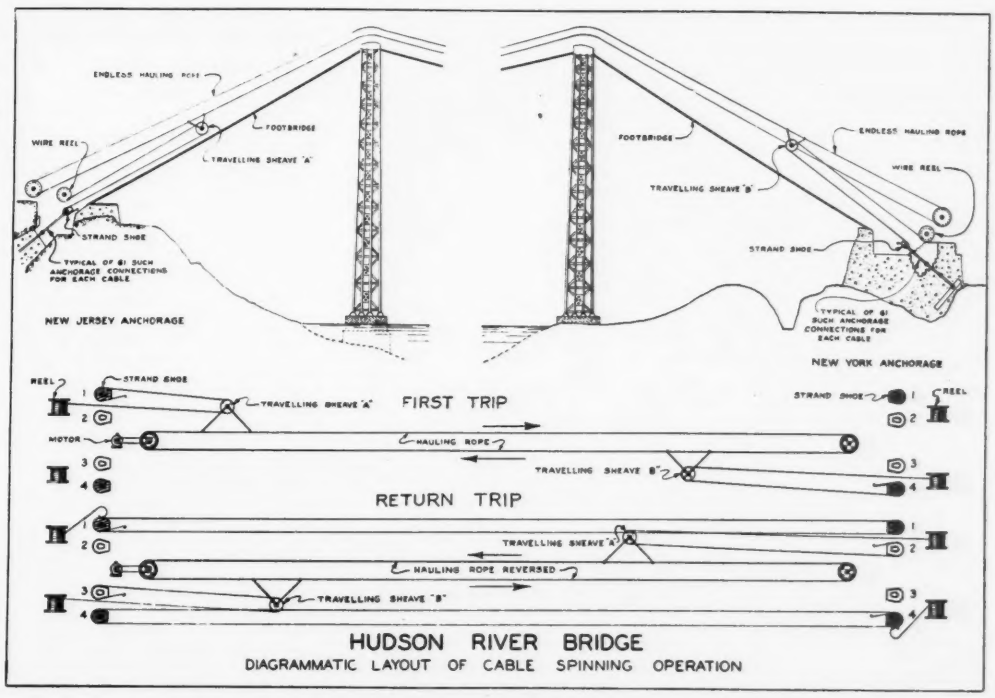
The foot bridges shown above are structures of a temporary nature for the use of workmen. They are suspended from wire cables nearly three inches thick.

The Hudson River Bridge

In collaboration with
DONALD G. FINK '33

Construction of the bridge towers, each of which must carry a load of over 100,000 tons, was begun in July 1928, and completed in less than a year. Because of the inconvenience of working unprotected at such a height, no work was attempted during the winter months. Each tower is arranged in two groups of eight columns each, sixteen in all, each group being used to support one pair of the four cables. The towers were erected in sections on panels, each braced for rigidity, and extending to a total height of 556 feet. The two legs of each tower are braced by arched trusses at the floor level and at the top. Silicon steel was used in all the main members, the bracing being of carbon steel. In the erection, use was made of a structural steel traveler, which at the start rested on the concrete tower base. From this position the first panel of both legs was erected. Then the traveler was hoisted to the top of the first panel and the erection of the second panel started from that point. The construction was thus completed, panel by panel, until the traveler had reached the top, and the erection was complete. More than a million field rivets were required to complete the work. Of particular interest in the riveting was the use of portable riveting scaffolds, or structural steel frames, supported from the tower steel work by blocks and tackle. As the riveting was completed in one section, the scaffolds were hoisted to a new position, and were thus able to follow the steel erection very closely. The accuracy was so great that when measurements were made at the completion of the tenth panel, the maximum difference in height between the longest and shortest column was only three-sixteenths of an inch. Correction was made, however, for this small variation when the remaining two panels were put in place. Elevators have been provided in each tower to be used for maintenance, and for future use by the public. The great height of the towers makes them exceptional vantage points for observation of New York City and the Palisades. Manufacture of the steel wire to be used in the suspension cables was started in January 1928. The wire, though of the same type as that used on the Brooklyn bridge and later structures, has been improved in quality and strength until it is nearly 50 per cent stronger than that used in the Brooklyn span. The steel is a high carbon, "open-hearth" type, drawn into wire by the cold drawn method, in which a billet rod is drawn through steel dies in four successive passes while cold. The result is a steel wire having a diameter about that of a lead pencil (0.192 inch) and a tensile strength of 230,000 pounds per square inch. Each wire was coated at the plant with pure zinc to prevent corrosion, and wound on reels in lengths of from 25 to 30 miles per reel.

The "spinning" of the cables is a laborious and tedious task. Before work could be started, extensive measures had to be taken to protect the workmen on the long span. The main feature of the preliminary work was the erection of the foot-bridges, of long wooden platforms suspended under the position to be occupied by the cable. These foot-bridges serve the purpose of temporary working scaffolds, above which the cable wires are hung. The erection of these auxiliary structures was started in July 1929, when the foot-bridge ropes, made of stranded steel, nearly three inches in diameter, were laid along the river bed, and then lifted to the top of each tower. On these ropes a wooden platform was erected over supporting steel, thus providing a continuous walkway from tower to tower. Along the side spans (from the tower to the anchorage), because of the greater slope, steps were substituted for the platform of the main span.



The cable spinning operations, which require the greatest possible co-ordination between the different units involved, were completed in August 1930 in a record time of ten months.

The spinning equipment was in place and the work of constructing the four cables begun in October 1929. Each cable has the unprecedented size of three feet in diameter, contains 61 strands of 434 wires each, and weighs more than a ton per linear foot. The total length of wire in all the cables, 105,000 wires each a mile long, would reach nearly half way to the moon. The wires are not spun, that is twisted, in the cable-building operation, but lie parallel from anchorage to anchorage.

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Fires and Engineering

BY HORATIO BOND '23

IT is apparent that the popular conception that fire was an Act of God prevented the early development of anything that might be called fire engineering. The code of Hammurabi, 2250 B.C., contained some elementary building laws, and early Roman law called for the construction of buildings with masonry walls and non-combustible roof coverings, showing that even in these early days some thought was given to fire safety. Crassus, an associate of Julius Caesar, is reputed to have run a private fire department. In 1580 a water system for the City of London was authorized. After the great fire of London in 1666 apparently some real thought was given to fire matters and a building law covering the construction of walls and other details which might be a factor in the start or spread of fires was enacted.

However, fire protection engineering, as such, can hardly be said to have developed before the middle of the nineteenth century. It came about through the desire of New England cotton mill owners to maintain uninterrupted production. It seemed obvious to them that attention to the construction, arrangement and protection of the mills had much to do with the chances of a serious fire. By applying common-sense engineering to these items, they were able to materially reduce the fire hazard of these properties. The success of their efforts led to the application of fire prevention and protection methods to other fields. This was a development of tremendous importance to the insurance business as it meant that in return for a good fire record, insurance companies could grant reduced rates to given classes of property. This made possible the insurance rating systems in general use today which, so far as possible, make each class of property pay a rate in proportion to its fire record.

The private fire department of Caesar's time has been mentioned. Early fire-fighting methods were undoubtedly crude, consisting largely of the use of water applied by buckets or syringes. One of the first pumps was developed in Germany in 1657, and flexible hose was invented by a Dutchman in 1672. Fire department technique has been much the same for many years: to rush rapidly to fires and throw as much water as possible. This practice prevails, strange to say, even in many of our modern cities.

When the engineering method was applied to the protection of buildings from fire it was obvious that the haphazard practices of fire departments in the early nineteenth century were unsatisfactory. Accordingly, it became the practice of industrial plants to provide private water supplies, piping systems, and hydrants from which water could be conveniently used on any fire. Having water-piping systems throughout the plant, it was a fairly easy step for engineers to conceive the idea of automatic sprinklers. Water piping was extended so as to reach every portion of every building and on these pipes at frequent intervals sprinkler heads were placed. These heads were arranged in simple fashion to operate by a fusible link which any fire would set off. Practically all industrial property and much mercantile and other types are under protection of automatic sprinklers today. Conservative estimates place the losses in property under sprinkler protection at only ten to fifteen per cent of losses in similar property without this protection, which will give some idea of its value.

Many of the developments which are adding a great deal to the comfort and convenience of our modern facilities have introduced fire hazards, the control of which would seem difficult. These have taxed the ingenuity of the scientist, chemist, and engineer in unbelievably diverse fields. Electric refrigerators in some instances have involved highly inflammable refrigerants. Technical research has made possible the substitution of non-inflammable gases or liquids for the more hazardous ones in many cases.

A view of the recent conflagration in Nashua, New Hampshire, which destroyed several important manufacturing plants and lumber yards, as well as over two hundred dwellings and other buildings. In this, as in many other conflagrations, wooden shingle roofs were an important factor. Such roofs ignite very rapidly from small sparks, and in turn produce flying brands, the result of which is a fire that spreads rapidly and soon gets out of control.

How much of the water from the hose streams shown is actually going on the fire? Fighting the fire from the outside is at best less satisfactory than fighting by devices permanently installed within the building, such as automatic sprinklers which put water directly on the fire.

The death of 124 persons from the inhalation of fumes of decomposing photographic X-ray films at the Cleveland Clinic a little over a year ago startled the medical world as well as the public at large. The hazard of nitro-cellulose film was, however, well known to fire protection engineers. The disaster was the direct result of storing film in a manner known to be unsafe.

Almost all except mineral dusts when mixed with air in proper proportions explode readily. These explosions are in many cases almost as severe as explosions of gasoline and other inflammable liquids. In the study of the chemical reactions during these explosions extensive chemical research has been necessary. The structural engineer, too, has not been idle. He has built structures in which dust or solvent vapor explosions may occur and be properly vented to the outside air, thereby keeping the building intact.

There is hardly space to enumerate more than these few instances, but the hazards of combustible fibres, inflammable liquids, and other inflammable and explosive substances are requiring the earnest attention of scientists and engineers who are looking at every new development in industry or elsewhere from the viewpoint of "How does this affect the fire hazard?"

A word would be appropriate as to the field in which the fire protection engineer works. Many of these are employed regularly by insurance companies and by their rating and inspection boards and bureaus. Engineers are needed to control fire hazard conditions in industry, for where an insurance company is accepting an industry or other risk for a low rate on the basis of a low fire hazard it must see that no unreasonable hazards are introduced. Fire protection engineers are also in the employ of private interests such as railroads, chain stores, trade and other organizations which have large and widespread burnable values to supervise.

Recent researches at the U. S. Bureau of Standards are doing much to make fire protection a quantitative science. It seems perhaps a little strange that fire, ordinarily considered a capricious element, can be measured with relative accuracy, yet just that is being done. The duration and severity of fires in various types of occupancies have been studied and within certain limits it is now possible to predict exactly how serious a fire may be expected in any given occupancy. This is of tremendous economic importance as it has made possible enormous savings in the construction of fire resistive buildings designed for low hazard occupancies. For example, first class, or fire resistive construction, has for many years been defined as a type of construction that will resist fire for four hours or more. In offices, hospitals, apartments, hotels, schools, and other similar low hazard occupancies, it has been found that it is seldom possible to have a fire which would last more than one or two hours if the building itself cannot burn. It is obviously poor engineering to insist that such a building be of a type of construction which will resist fire for four hours.

Most of our fire departments are happily evolving from the old-fashioned type of water-throwing organization, and a few, notably Los Angeles and Detroit, have developed divisions with a staff of inspectors who devote all their time to fire protection engineering matters. The last few years have seen a considerable impetus given to this development and it is reasonable to expect that the fire department in the future will consider fire protection engineering their primary func-

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Photograph by Hugh Miller

A building burned for science! Physicists of the Bureau of Standards recently made a fire test by burning a full-sized building under controlled conditions in Washington. The building was filled with thermocouples, enabling temperatures of all parts of the structure to be read during the fire; other accurate technical data was also kept. This data and that developed from other tests is helping to make fire protection a quantitative science.

The Ultra-Violet Microscope

BY FRANCIS F. LUCAS

Telephone Apparatus Development, Bell Telephone Laboratories

AS an offshoot of its development for metallography, the ultra-violet microscope has become available as a new tool for biological research. Not only does it give about twice as much detail as the best lens systems for visible light, but it largely obviates the need of staining the subject and it allows photographs to be taken at slightly different focal planes or levels, thereby giving a consecutive record of the architecture of the cells.

Nearly thirty years ago, following the lead of Professor Abbe in matters relating to improvements in resolution by means of microscopic vision, Dr. A. Köhler of the Zeiss Scientific Staff developed the ultra-violet microscope for use in the field of biology. It had a potential resolving ability twice that of the best optical system using visible light. The equipment was made available to scientists by the firm of Carl Zeiss and some sporadic work was done by different investigators but no outstanding accomplishments appear to its credit. Difficulty in manipulation and inability to focus the equipment seem to have reacted against the widespread use of the ultra-violet microscope.

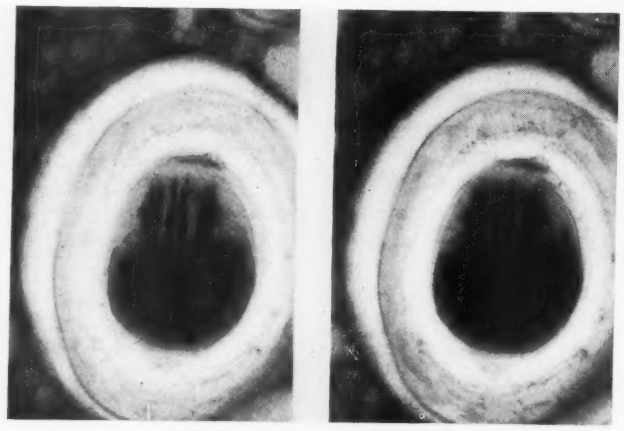
Nearly ten years ago, following the development of high power metallography and the utilization of the full potential resolving ability of the best apochromatic systems using visible light, Bell Telephone Laboratories arranged with the Zeiss Scientific Staff to design an ultra-violet microscope suitable for metallography and for transparent specimens.

The lens system of the microscope is of quartz, since glass does not transmit ultra-violet light. Since it is impossible to correct the lenses for light of a number of wavelengths, quartz prisms are provided to resolve the light from a spark gap into its components, and only one of these is admitted into the lens system.

Since we are dealing with invisible light the optical image cannot be seen in the ordinary way. It must either be photographed or visualized on some sort of a fluorescent screen. The fluorescent screen takes the form of an artificial eye, which is a uranium glass wedge incorporated in a small optical system and mounted interchangeably with a camera just above the ocular. The surface of the wedge on which the image is to be received has two cross lines. These cross lines are brought into focus by a small magnifier. Then the fluorescing image of the object is focussed on the plane of the cross lines by the adjustments of the microscope in the usual way. When the image is once in focus in the artificial eye or searcher eyepiece as it is called, the calculations of the optical system are such that it will be in focus in a plane 30 centimeters above. The camera is then substituted for the searcher eyepiece and a photograph taken. After working with the equipment as a metallurgical microscope it soon became evident that a more exact method of focussing must be devised than the "searcher eyepiece" method of Köhler. Briefly, the focus must be exact to a hundred-thousandth of an inch. To accomplish this certain additions have been made to the mechanical system of the microscope. The microscope is fitted with a graduated half circle which has a slider, also graduated, each division equalling four degrees. The knurled thumb screw of the microscope slow-motion is fitted with an aluminum pointer which may be easily and quickly placed in position or removed.

The method of operation is as follows: The image in the searcher eyepiece is brought into approximate focus by the usual methods. The slow-motion is then turned so that the instrument passes through the focus and then it is very gradually brought back. In this way all lost motion in the slow adjustment is compensated for by gravity. A very nice mechanical balance must be obtained in the moving parts otherwise the method will fail. Any "creep" or change in focus even though very slight will upset the whole method. The personnel element perhaps is still most important because the method relies on the keenness of vision of the operator to bring the image in the searcher eyepiece just to the stage of coming into focus. The pointer is then set near the middle of the scale and the slider moved so that the first graduation coincides with the pointer. A photograph is taken with the apparatus in this position; the pointer is then lowered one degree which corresponds to a change of one hundred-thousandth inch in elevation of focus, and a second photograph is taken; and so on. Four photographs taken in this way of a metallurgical specimen are sufficient to provide one photograph in exact focus.

It appeared logical to assume that any optical system which will yield a very sharply defined focal plane to an accuracy of about one-quarter micron should prove to be of great value. For example, if a transparent preparation is used instead of a polished and etched metal specimen then it should be possible to photograph the details of structure on different planes within the transparent specimen.



Magnified 1025 diameters, a living embryo of a tapeworm was optically sectioned in these photographs. Had the mouse in whose body this embryo was found, been eaten by a cat, the embryo would have developed into a tapeworm within the cat's body. Tapeworms are usually propagated through food.

This development has been described by Dr. E. E. Free, who likens a single cell to a house; and he has imagined what he would see if the house were divided by equally spaced cutting planes. I shall adopt Dr. Free's analogy to make clear what actually does happen when living cells are so sectioned.

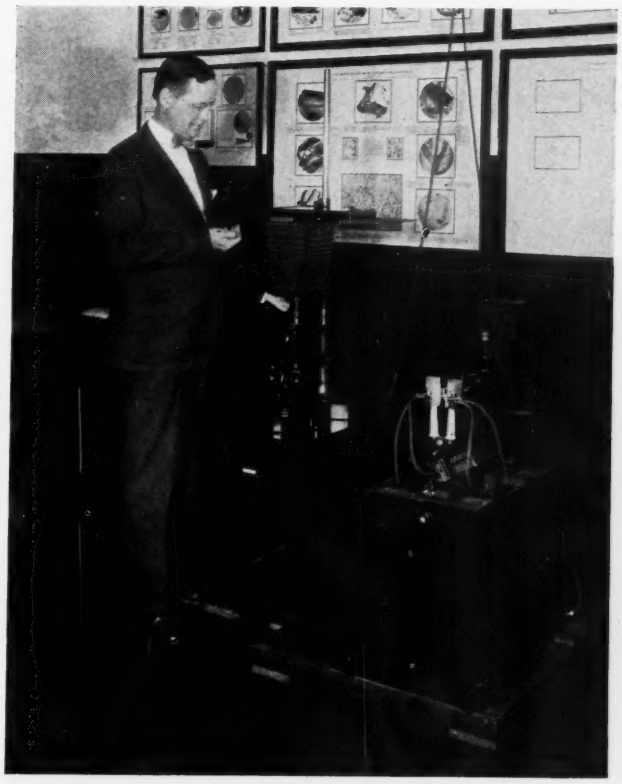
First we may take a photograph on a plane cutting through the attic. We do not see the roof above or the floors below. We only see the details on the exact focal plane selected. Perhaps there will be trunks,

bags, boxes and things of another day placed in the attic for storage. All of these things on the focal planes are clearly defined. Perhaps our focal plane cuts midway through a trunk; we do not see the top or bottom of the trunk but we see the things which are stored away within the trunk and which are intersected by the cutting focal plane. In one compartment of the trunk our focal plane has come on some woolens. We see the texture of the cloth and observe that it shows wear and then we come on the handiwork of the moth larvae. In another compartment are some queer-looking sections of straw and cloth and wire and we decide that it must be a hat on which the sun has risen and no doubt set for the last time. And so we could investigate the contents of all trunks, bags, and boxes without opening them, disturbing their contents or doing the slightest damage.

And so we may go from room to room and from floor to floor observing the life and habits of the occupants. If we take photographs as we go, the photographs taken to scale may be laid out in order from top to bottom and a working model of the house constructed.

Fortunately, our private lives are not open to such scrutiny as the hypothetical example just cited, though it does describe on a large scale what we are now able to do with many living things.

By means of this development, a transparent specimen such as a single living cell or a group of living cells may be sectioned optically. The focal planes may be spaced as closely as a hundred-thousandth of an inch. Detail above or below the focal plane does not interfere. Successive photographs taken on planes, as illustrated in the photographs on the opposite page, give a progressive record of the structure within the cell.



Mr. Lucas ready to take a picture with the ultra-violet microscope.

Magnifications of 3,600 diameters or even higher result in crisp, brilliant images with a degree of resolution (ability to reveal line detail), surpassing by far that achieved with any other known optical system.

The method is equally applicable to fixed and stained specimens, but, except in unusual circumstances, it is always desirable to use living material. In the final analysis, biologists are interested in the structure, functions and behavior of the living undisturbed cell. Fixation and staining create an artificial condition from which one must reason back by deduction.

Köhler pointed out many years ago that one advantage of the ultra-violet microscope lay in the fact that organic specimens are differentiated in structure by virtue of the selective absorption which they manifest toward ultra-violet light. When using visual light microscopes, the need for staining biological specimens is too well known to need comment here. Unstained specimens respond under the ultra-violet microscope much as though they were stained. It is generally recognized that the structure of organic material is apt to be profoundly altered by the treatment in preparing it for microscopic examination. The trend in cytological research appears to be toward the study of living material thus avoiding arti-facts induced by fixation, staining and mounting. The advantages of this selective absorption of organic matter for ultra-violet light will be readily appreciated if one wishes to photograph living material. There are two reservations which must be borne in mind. The ultra-violet light itself must not have injurious effects on the organisms and the organisms must not completely absorb the ultra-violet light.

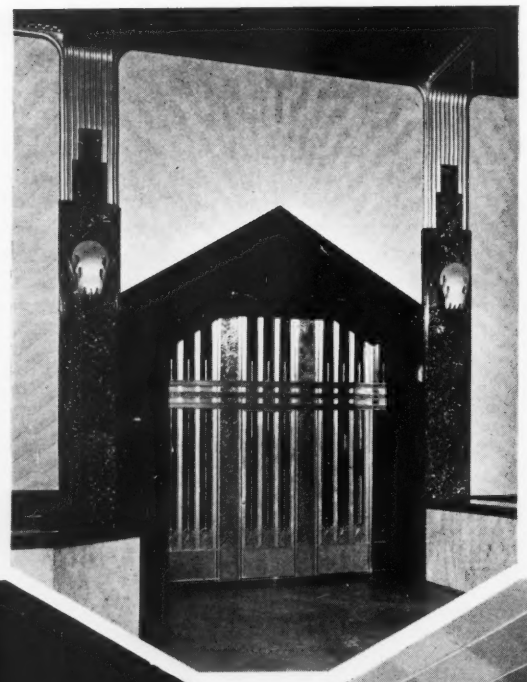
Differences in structure in living things almost always mean differences in chemical composition. For example, it is well known that the cytoplasm of a living cell is different chemically from the nucleus and when a living cell is photographed with the ultra-violet microscope, the nucleus is well differentiated from the cytoplasm which surrounds it. These, however, are gross details of structure. The nucleus contains many small bodies and usually there are inclusions in the cytoplasm. Many such details differ, if even slightly, in chemical composition and this difference in chemical composition is recorded on the photographic plate.

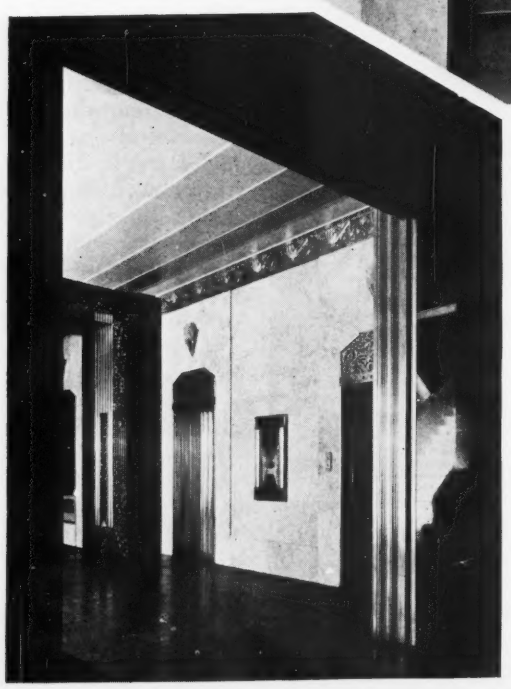
Ultra-violet light of the intensity and wave length used in conjunction with the the ultra-violet microscope appears to have little if any harmful effect so far as many types of living cells are concerned. It is true that some single cell organisms are destroyed almost instantly; others of another species in the same mixed culture appear mildly excited and others immune. From some preliminary observations, it appears that living cell cultures may be exposed under the ultra-violet microscope for as long as forty-five minutes and, when returned to the incubator, they appear to grow without ill effects from the exposure.

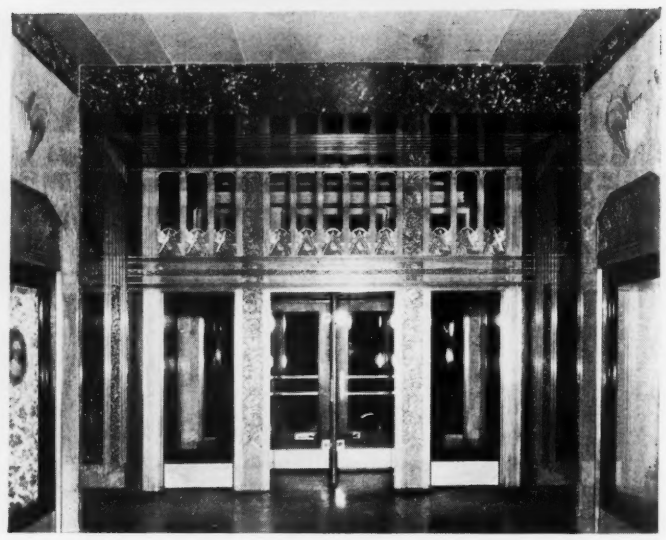
Briefly, the ultra-violet method of microscopy requires a number of refinements for successful operation. A narrow band of ultra-violet light frequencies, a quartz lens system, a highly sensitive adjustment of focus, and a special viewing device are among the main essentials. The advantages to be obtained through its use are many, however. High magnification with unusual clearness of detail, the ability to photograph in different planes, the processes of living organisms in their natural state are among the unique features of the system. The aid rendered biological research in the study of micro-organisms is readily apparent, and increasing use of the instrument is being made in many other branches of science.

Editor's Note: The excellence of this article by Mr. Lucas, which appeared recently in the *Bell Laboratories Record*, is so apparent that the staff feels fully justified in reprinting it in its original form. So clear an exposition of this modern branch of optical science should form a worth-while addition to any technical publication.

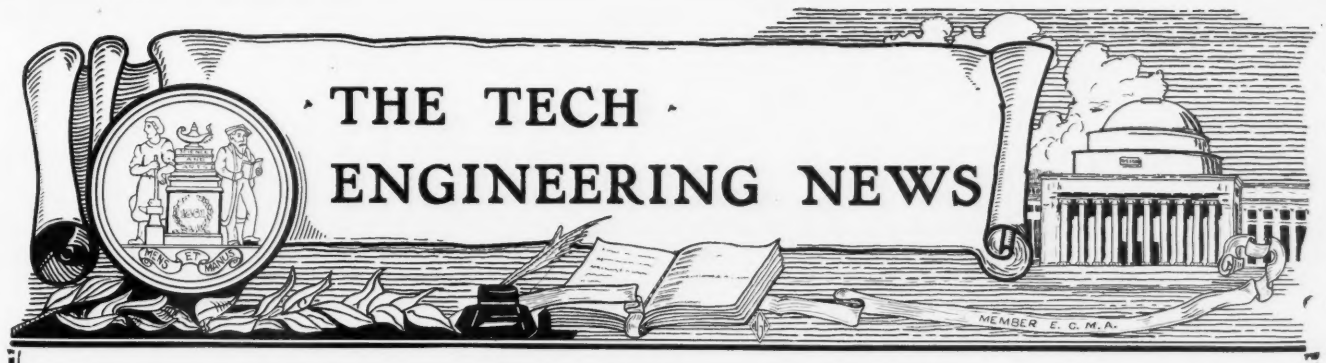
Modernistic design has already been accepted for various types of buildings, such as apartments. So well have they been received that this type of decoration has been adapted to use in commercial structures. The building whose interior is illustrated in these photographs is that of a prominent Chicago bank, and is one of the first to be so decorated. Free use was made of structural aluminum for such items as the various grilles and entrances. These parts comprise probably the largest ornamental aluminum installation in the world. Wainscoting and columns are of Vermont marble.







Modernism in Architecture



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Editorials

WELCOME, '34!

THE TECH ENGINEERING NEWS desires to join in the sincere if somewhat multitudinous good wishes that are being extended to the incoming Freshman class. Those of us who slightly weatherbeaten sometimes think that it will need all the good wishes it can get! It is true that the road to a diploma is more difficult than that at some other colleges which the members of the class might have selected; yet even the most cynical of us will not deny that whatever extra effort we may expend is worth the trouble. In selecting M. I. T., the incoming class has selected wisely. The Institute has the advantages of a fine instructing staff, unrivalled equipment, and a good reputation. All that is necessary to take the fullest advantage of these is a serious purpose and a reasonable amount of work. They are ready for the use of the Freshmen.

It is the privilege of THE TECH ENGINEERING NEWS to aid in a small way the Institute's work. It publishes articles of general and particular interest, tying in closely with the various courses offered by the Institute. Its scope is broader than any of the professional journals. By reading THE TECH ENGINEERING NEWS one can keep in touch with the work not only of his own field, but also in a general way with others.

THE TECH ENGINEERING NEWS is entirely a student publication. It is run entirely by undergraduates for the benefit of students and alumni. A Freshman who has a tendency toward publication work could do no better than come out for it. Not only for the sake of publication work itself is it valuable, but keeps the candidate in touch with men about the Institute and in the engineering field in general. The contacts which men on the publication make are always a source of pleasure, and sometimes form a valuable asset. If one wishes to have an acquaintance that lies beyond the bounds of his course, he will have to put forth special effort. There is no better way than coming out for THE TECH ENGINEERING NEWS. There is ample opportunity both for men inclined towards the business end and for men editorially inclined. To the fortunate managerial positions are given in the middle of their Sophomore year. Freshmen will always be welcome in the office in the basement of Walker Memorial.

MANAGING BOARD CHANGES

THE TECH ENGINEERING NEWS regrets to announce the resignation of Christian E. Grosser '31 as Business Manager. Nelson B. Haskell '31, the Advertising Manager of the previous volume, will take this position.

Engineering Notes

Flaked Ice, a new fast cooling, easily marketable form of ice, which can be manufactured speedily and cheaply, has been introduced to the general public.

An automatic machine enables this ice to be made continuously. The form on which the ice is frozen is a drum of thin metal sheets, bound together by rubber strips. This drum, driven by an electric motor, revolves in a tank of water. Brine, cooled to 12 degrees F., is pumped into the drum, and sprayed on the metal walls. At this temperature a thin film of ice will freeze on the outside of the drum. At a predetermined time an eccentric on the driving shaft will cause rollers on the inside of the drum to press out against the thin sheets, changing the shape of the drum. This cracks the film of ice, and allows it to peel off and float to the surface, where a conveyor scoops it up and delivers it to the chute leading to the bins. The ice thus made, since it is cracked by the peeling process, appears in the form of small thin flakes, which are easily handled, may be packed in attractive cartons, or sold in bulk.

The future of this new form of ice should be bright. Due to the large surface per volume of the flakes, they melt, and consequently cool much more than ice cubes or crushed ice. They can be used for packing food, supplanting crushed ice, and also used extensively in the household for cooling outside of the refrigerator.

Courtesy *Rock Products*

The transit mixer is shown in a position for discharging its load.

Transit-Mixing Concrete Trucks are proving their worth in building in congested areas. Unlike the older type of truck, which carried ready mixed concrete, these trucks load up with dry ingredients which have been carefully proportioned. On the way to the job the dry materials are mixed thoroughly, until when the driver is about four minutes from the location he pulls a lever near his seat which releases a measured amount of water into the dry materials. Thus, when the truck arrives at the building it is ready to dump its load into the forms. On the way back to the gravel pits, etc., the driver turns on a new supply of water so that the drum is washed out.

Colored Aluminum, produced by a recently developed process not only enhances the beauty of the metal but also adds many desirable physical and chemical properties. The coloring, which may be silvery white, jet black, or shades of red, blue, yellow, green, and purple, is a part of the aluminum itself and will not peel off. The metal may be stamped and formed without fear of marring the finish.

The surface produced will take paints and lacquers with greater ease than ordinary aluminum and the coated part has a higher melting point than the pure metal. The color offers resistance to atmospheric and salt water corrosion and also resists certain chemicals. It may well be adapted to many industries including the manufacture of cooking utensils as a jet black kettle conducts the heat better and water boils in a shorter time than if the kettle were bright aluminum.

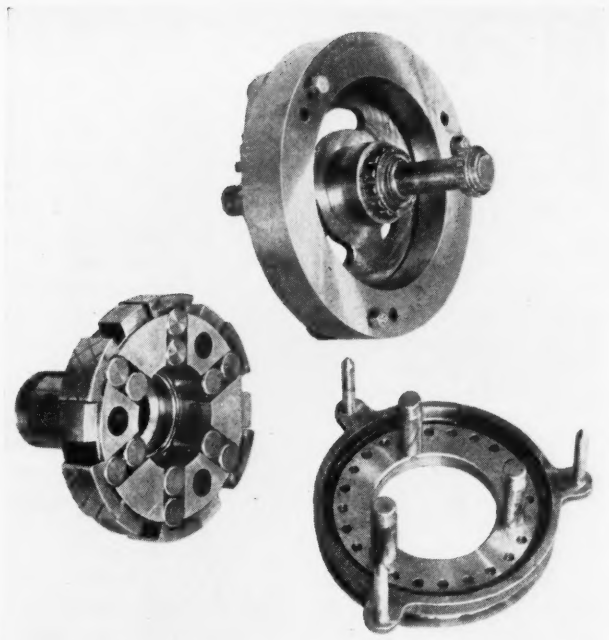
Air Transport Communication between plane and ground or between two planes has been practically solved. For years this important phase of air transport has baffled radio and electrical engineers but recent developments have produced excellent results. Best results have been obtained when the plane is flying at high altitudes, both strength and clearness being improved.

The antenna presents a great problem in the radio-telephony. Military aircraft use the lower frequency bands and a long antenna for best results, but transport planes cannot carry a long trailing wire. A short antenna consisting of hollow wooden mast with an internal conductor makes a good aerial for receiving purposes when mounted on the fuselage. In order to use a small antenna for transport work the planes must be confined to the higher frequencies which are less suitable for the work.

A few other difficulties in the airplane that have to be overcome are the terrific noise and the many stray electric currents set up by the ignition systems. The noise objection is overcome by special headphones and telephones and the electric disturbances are stopped by shielding all points of disturbance. In transmitting the sets must also be shielded so that the high voltage will not produce arcs which would be very dangerous.

Radio reception in airplanes is fairly advanced. The receiver is a comparatively simple set, mounted in a box twelve inches long and eight inches high weighing but thirteen pounds. Power is generated by a small electric generator driven by a one-bladed propeller. The centrifugal force of the unbalanced blade actuates a governor so that speed and output remain constant no matter what the speed of the plane may be.

Cylinders in a New Airplane Engine are parallel to the crankshaft. This reduces to a great extent the resistance offered by the ordinary air-cooled engine, but a very difficult feature of design is converting the



Courtesy *Machine Design*

This system of rollers and wedges of which the free-wheeling device is made up permits one to shift the gears of an automobile without the use of the clutch.

reciprocating motion of the piston into a rotary motion in an entirely different direction and plane. This has finally been accomplished with a good degree of efficiency.

In the engine, designed in England, seven air-cooled cylinders are placed in a circle so that the pistons vibrate along the longitudinal axis of the plane when installed. The crankshaft is made in a Z shape with a connecting system with a shape similar to that of a star. As a piston is forced down, or rather back by the explosion, the star-shaped connection is forced to revolve about an axis through the center of the crankshaft but at right angles to it. This in turn forces the upper end of the Z on the crankshaft to fall while the lower end rises, causing the Z to revolve about an axis which passes through the extremities of the letter.

Besides lessening the resistance of the ordinary engine, the pilot is given a greater amount of visibility.

A Combined Aerator and Mixer for water recently placed on the market employs the injector principle, and thus avoids moving parts. Water enters the "mixing head" at the sides and in so doing passes by a number of tubes which are pointing in the direction of the current flow. This sucks air into the water and the rapid flow breaks the bubbles up so that there is a great deal of air in the water by the time it has travelled to the end of the nozzle a few feet lower.

Through this nozzle chemicals for the purification are introduced. The thoroughly aerated water induces an excellent mixing action and the chemicals are well diffused, which action is also aided by baffles placed on the inside of the tube. A head of only five to eight feet gives good results and operates the mixer with entire absence of moving parts.

The Free-Wheeling Device for automobiles presents an innovation in driving. The unit, which is really an automatic metal-to-metal clutch, is inserted into the propeller shaft of the car. The whole mechanism is a system of rollers and wedges which disengage the engine from the drive shaft as soon as the engine revolutions fall below the speed of the car. Thus, as soon as one's foot it taken off the accelerator the engine revolutions die away to idling speed while the car coasts along.

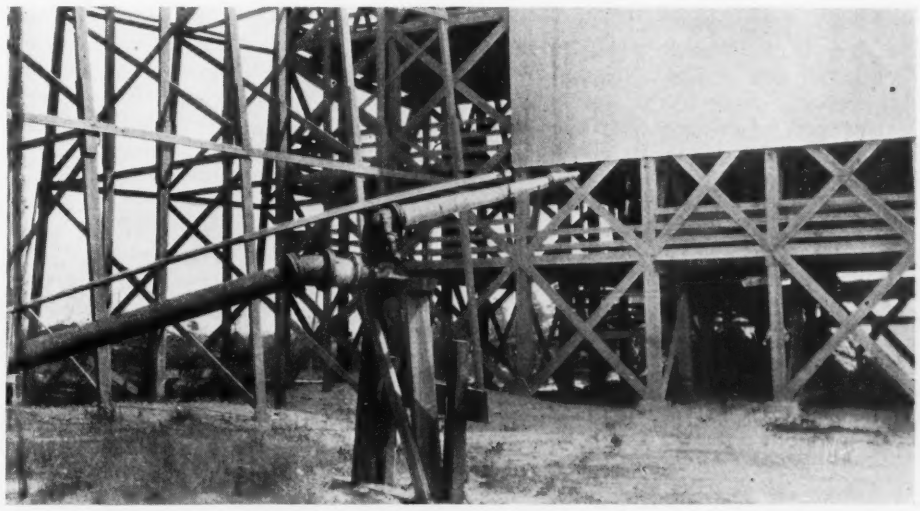
It may be easily seen that because of the above, it is not necessary to disengage the clutch to change gear, and any gear may be selected, no matter what the speed of the car. As soon as the gears are meshed, and the accelerator pressed down the load is again taken up by the motor. The clutch must be disengaged when starting from a standstill, however, as the engine revolutions are greater than the speed of the shaft and the automatic clutch will not be released.

Naturally, with such a device, there is no "piling up" of the engine when the accelerator is released. While this is an advantage on level roads, it is a disadvantage on hills as one must rely entirely upon one's brakes to hold the car, because the engine will not.

Old Hydraulic Guns which have served their purpose in mining are now being utilized by a southern concern to protect its buildings from fires. The old guns have been set up near the buildings as shown in the illustration, pointing directly at them. In case of fire the pumps which formerly supplied the guns are turned on and a powerful stream of water is projected at the building.

Because the buildings it protects are not near a fire-water system as in modern cities, this serves as such. In fact, it is much more effective as not only is the water under a higher pressure, but the whole system, from reservoir to nozzle, is built of pipe. Consequently there is no hose to rot or be cut or disabled when it is needed most.

It operates under so large a pressure that it could wash the building away if such a thing were ever necessary.



Courtesy *Rock Products*

This old hydraulic gun has been set up as a fire extinguisher. In case of fire a powerful stream of water can be turned through the gun onto the building.

Recent Books

SKY HIGH. *By* ERIC HODGINS '22 and F. ALEXANDER MAGOUN '18. *Little, Brown & Company, Boston. 337 pages with index, illustrated. Price $2.50.*

Eric Hodgins and F. Alexander Magoun, two alumni of the Massachusetts Institute of Technology, have told in this book the story of aviation and man's desire and attempts to fly from the fourth century before Christ down to the present day. They have gathered together into one book material which heretofore has been widely scattered and was generally little known, and although they have written of the historic developments of aviation, it has been done in the manner of a story and with a great deal of humor. This humor is perhaps one of the most attractive features of their work, for the reader expecting a series of dry statements of facts is pleasingly surprised from the very first.

The early part of the book is devoted to accounts of the first aerial flights made by means of balloons. The difference between the weight of hot and cold air was used as the principle for the first of these, which were first successfully flown by the Montgolfier brothers of France. The early ascents were made without passengers of any kind, then later a sheep, a rooster, and a duck were given the honor of being the first living creatures to make a balloon ascent. After they had demonstrated that animals could safely rise into the air and safely descend again upon occasion, human beings consented to risk their lives. Jean-François Pilâtre was the first man to offer himself, and he made an ascent in a balloon constructed mostly of paper and linen with a wicker basket suspended below which contained a large iron grate upon which he stoked the raging fire of straw which heated the air to keep him aloft, the balloon being held at the end of an 84-foot rope. Later he made a free flight with a passenger, the Marquis d'Arlandes. During this voyage, as recorded in a letter of the Marquis', the fire burned quite a number of holes in the linen and paper of the balloon covering. The Marquis writes that he took a sponge and was easily able to extinguish the fire around the holes within reach, and that there was no danger to be apprehended.

The hot air balloon was soon followed by the hydrogen balloon, its development being followed until it evolved into the modern dirigible.

Man's long struggle to fly with heavier than air machines is also traced through history, from the early gliders to the Wright brothers' first power-driven flight, and then on to the swift growth of aeronautical development of the present time. The early pioneers of each phase of the progress made are sketched, and the contributions which each has individually made to the furtherance of flight is shown. Not only are the men who contributed to the progress of aeronautics by their successful work pictured, but some space is also given to those who tried and failed, who perhaps had the right principles but lacked the proper materials to put into execution their ideas — the men who had lived before their times.

To those interested in aviation this book will give a background of what those who have gone before have done, and will show what the present owes to the past.

THE NEW WORLD OF PHYSICAL DISCOVERY. *By* FLOYD L. DARROW. *The Bobbs-Merrill Company, Publishers, Indianapolis. 371 pages. 14 illustrations. Index. Price $3.50.*

"The New World of Physical Discovery" has been written to open the door of the science of physics to the layman, and for that reason the first part of the book is devoted to some of the fundamentals, developed with the historical background and written in a popular manner. Any student at the Institute who has completed the two years of required physics work will have studied all that is covered here in a far more detailed and mathematical form, in fact this book makes no pretence of mathematical treatment.

After passing over this part, however, the reviewer's interest was aroused by the account given of the Einstein theory, really one of the most lucid non-mathematical explanations the reader has seen. Such difficult concepts as curved space, a limited universe, the fourth dimension, and the non-existence of a gravitational force were covered. The author shows how Einstein's theory in no way invalidates the Newtonian Law of Gravitation, but includes it as a special case in its larger and more general principle. Included in this section is a description of the Michelson-Morley experiment to detect the existence of an ether drift, the negative results of which indicate that no ether exists, but of course the acceptance of Einstein's theory with its absence of a gravitational force makes unnecessary an intervening medium through which this force can act. The experimental evidence was cited which has in every case vindicated Einstein's predictions and therefore his theory. The author concludes his chapter on Einstein and relativity by saying that Einstein, more than anyone else in two centuries among scientists, has knocked most successfully at the door of Nature's deepest mysteries.

Any book of this nature covers a big territory, because the science of physics is so big, including as it does everything from the structure of the atoms, the smallest entities of which we know, up to such stars as Betelgeuse, which are among the largest. The latter part of the book combines these two, the smallest and the largest, in explaining the scientific concept of how the stars generate most of their immense heat, by a process of changing matter into energy through the destruction of matter itself. Electrons and protons meet and are annihilated through the neutralization of their charges, giving rise to vast quantities of radiant energy, according to Einstein's mathematical expression, where the energy produced is equal to the mass times the square of the velocity of light. Thus we are shown how the sun is wasting away its substance in giving off the energy it does.

We at Technology are familiar with the second law of thermodynamics and the increase of entropy in the universe, according to that law. We know that according to it a time will be reached when all of the heat energy will become level, and there being no difference in potential, it will be impossible to utilize it. This holds true if there is no return reaction, no creation of new energy, to replace that constantly being thrown out and wasted by radiation into interstellar space. Until Millikan, there seemed to be no chance of any such cycle. But Millikan, Darrow explains, in his discovery of cosmic rays, which come with equal intensity from all portions of the sky, has indicated the possibility of the re-creation of matter from the radiant heat and light energy constantly being lost in the depths of space. Millikan does not know by what means that process would take place, but believes that it is taking place, and that energy is being turned again into protons and

(*Continued on page 206*)

STEPPING INTO A MODERN WORLD

A group attack on the "X" of industry

Research, finding answers to the eternal x = ?, keeps step in the Bell System with the new industrial viewpoint.

The joy in working out studies in development is shared by many. Results are reached by group effort. Striving together, the mature engineer and his younger assistants, each contributes to the final solution of the problem.

Men of the Bell Telephone Laboratories are sharing in useful, interesting research. They are getting valuable training in the modern strategy of organization attack.

And because that strategy assures them the aid of men and material resources, they are actually turning some of their vision into fact.

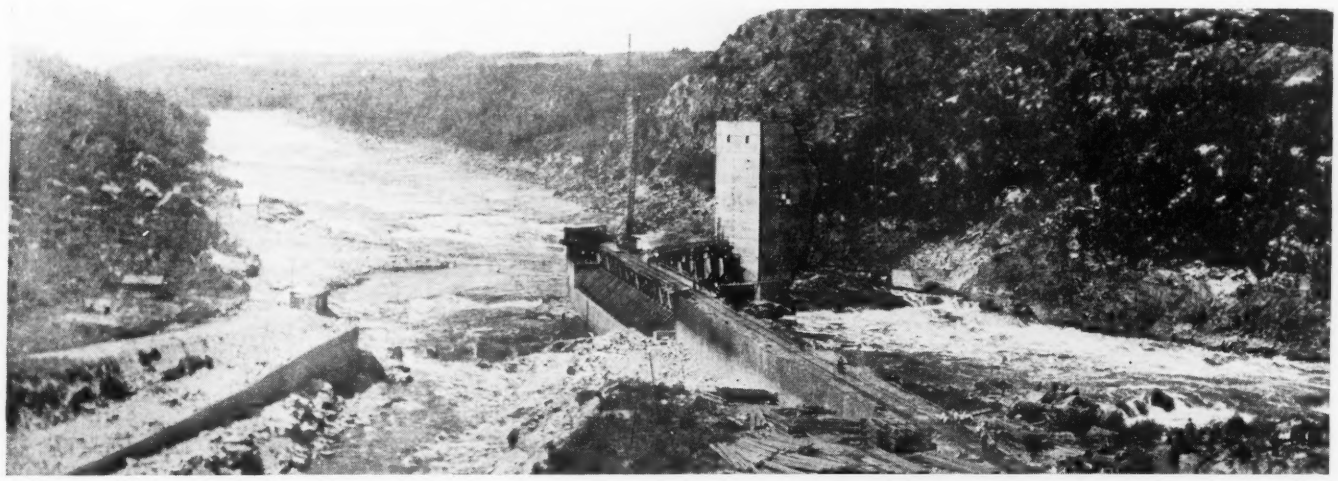
BELL SYSTEM

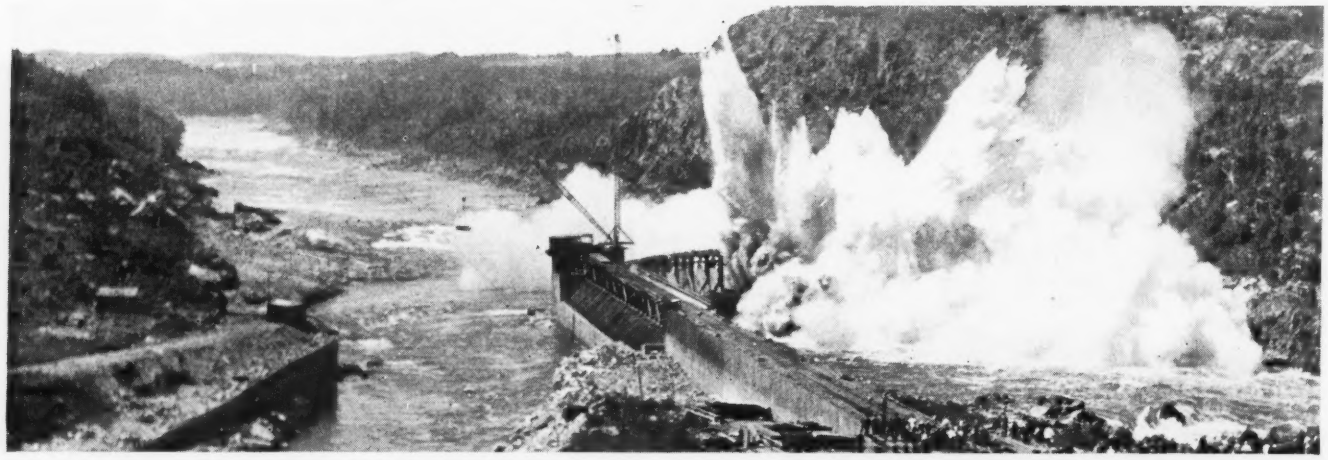
A NATION-WIDE SYSTEM OF MORE THAN 20,000,000 INTER-CONNECTING TELEPHONES

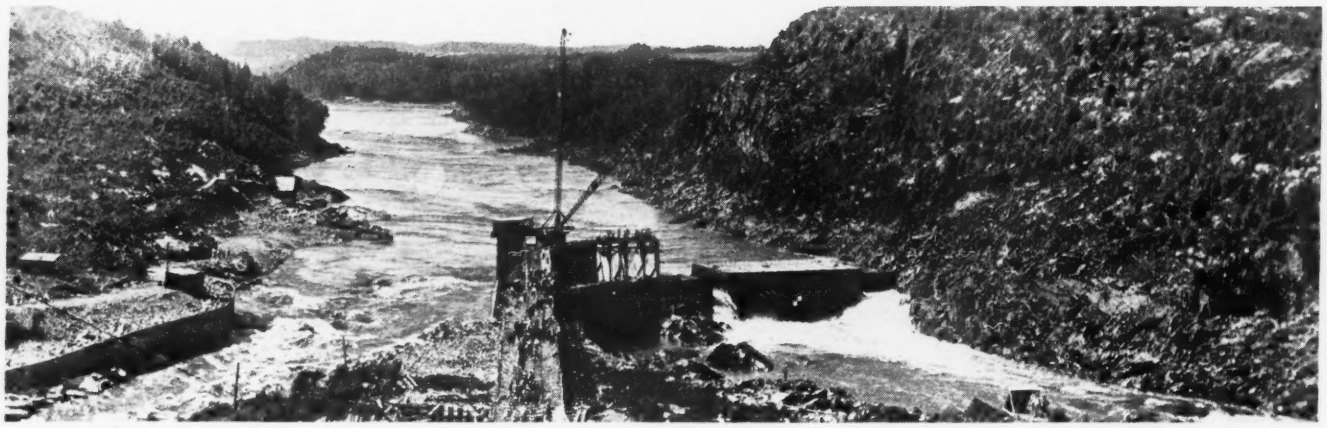
Saguenay River Diversion

CONFRONTED with the necessity of diverting the swiftly flowing Saguenay River in northern Quebec into a newly excavated channel, and prevented from using all ordinary methods of diversion by the 20 feet per second velocity and 40,000 second feet discharge of the stream, a novel method of damming the river was attempted.

While the diversion channel was being excavated at one side of the river, parts of the dam were built out from both banks, leaving the center section open. Then, on one side of the river, resting on two piers, a huge precast concrete dam, 92 feet long and 45 feet wide, weighing 11,000 tons, was constructed, as shown in the first of the following illustrations. The bottom was contoured to fit the river bed. When the time came to close the stream, the forward pier was blasted away, and the dam rolled over the other pier and fell into place within one inch of the calculated position. Thirty feet of running water cushioned the shock, and no damage was done to the dam. Once in position the three parts of the dam were sealed together, forming a very satisfactory cofferdam.







Courtesy *Engineering News-Record*

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

The MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses in Engineering and Science, each of four years' duration, leading to the degree of Bachelor of Science in:

AERONAUTICAL ENGINEERING
ARCHITECTURAL ENGINEERING
BIOLOGY AND PUBLIC HEALTH
BUILDING CONSTRUCTION
CHEMICAL ENGINEERING
CHEMICAL ENGINEERING PRACTICE
CHEMISTRY
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
ELECTROCHEMICAL ENGINEERING
ENGINEERING ADMINISTRATION
GENERAL SCIENCE
GENERAL ENGINEERING
GEOLOGY
INDUSTRIAL BIOLOGY
MATHEMATICS
MECHANICAL ENGINEERING
METALLURGY
MILITARY ENGINEERING
MINING ENGINEERING
NAVAL ARCHITECTURE AND MARINE ENGINEERING
PHYSICS
SANITARY ENGINEERING

The Course in Architecture is of five years' duration, and leads to the degree of Bachelor in Architecture. Five Year Coöperative Courses in Electrical Engineering and Railroad Operation leading to the degrees of Bachelor of Science and Master of Science are also offered.

Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Coöperative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

Any of the following publications will be sent free upon request:

CATALOGUE FOR THE ACADEMIC YEAR
(WHICH INCLUDES THE ADMISSION REQUIREMENTS)

SUMMER SESSION CATALOGUE

GRADUATE STUDY AND RESEARCH

Correspondence should be addressed to the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Departmental Notes

DEPARTMENT OF CHEMISTRY

New Instructors in Freshman Laboratories

Three new instructors have been appointed in the division of inorganic instruction. Dr. Arthur R. Davis comes from Harvard where he has been an instructor in the chemical laboratories while pursuing advanced studies. Before entering Harvard for graduate work, Dr. Davis enjoyed a period of eight years of teaching at Middlebury College. Dr. Edward J. Salstrom carried out his advanced studies at the University of California. He brings to the Massachusetts Institute of Technology his experiences in the great chemical laboratories headed by Prof. Gilbert N. Lewis. Dr. S. C. Collins completed his work for the doctorate at the University of North Carolina in 1927. For the past three years he has been teaching in the State Teachers' College at Johnson City, Tennessee.

Resignation of Dr. Hunt

Dr. Herschel Hunt has resigned his post as instructor in inorganic chemistry to accept a position of Assistant Professor in the Department of Chemistry in Purdue University, Indiana.

Research Assistants Appointed

Two research assistants have been appointed in the Department. Mr. Samuel F. Allison will be in the Research Laboratory of Physical Chemistry. Since completing the work for the Master's Degree at George Washington University, Mr. Allison has been engaged on some problems of fractional distillation under the direction of Dr. Edward W. Washburn at the Bureau of Standards in Washington. Mr. Clement H. Hamblet has been appointed Research Assistant in the Research Laboratory of Inorganic Chemistry. He will assist Dr. Ralph P. Seward in the investigation of solubility relationships in non-aqueous solvents, especially those of low dielectric constant.

New Teaching Assistants

The group of teaching assistants has been brought up to strength by six new appointments to fill the vacancies left by resignations at the end of the past school year. Mr. Robert F. Armstrong, Mr. George E. Barker, Mr. Emanuel B. Hershberg, and Mr. David Rubinstein will be in the division of Organic Chemistry. Mr. Richard L. Berry will assist in the laboratories of Analytical Chemistry. Mr. Leonard L. Leum will assist Professor Gill in the laboratory for proximate analysis. Mr. Leum comes to M. I. T. from St. Olaf College in Minnesota. The other five assistants have had their training at the Massachusetts Institute of Technology.

Visiting Professors

During the summer three professors from other schools have been engaged in special researches in the Research Laboratory of Physical Chemistry. Dr. Louis J. Bircher, Professor of Physical Chemistry in Vanderbilt University, in Tennessee, has been associated with Dr. Gerhard Dietrichson in an investigation on the densities of gases. Dr. Melville J. Marshall, Professor of Physical Chemistry in the University of British Columbia, has been completing an investigation on adsorption. Prof. Paul T. Jones, of Louisiana College, has been making accurate measurements on the freezing points of dilute solutions.

Professors Abroad During the Summer

Prof. Frederick G. Keyes was a delegate to the International Steam Conference held in connection with the World Power Conference in Berlin in June. The meeting was concerned with the correlation of data on the properties of steam up to extremely high pressures and temperatures. Professor Keyes was also a delegate to the Union International de la Chimie, held at Liege in September.

Prof. H. Monmouth Smith has been travelling in Germany. He spent considerable time in studying the Deutsches Museum in Munich.

Professor and Mrs. James F. Norris have spent their summer vacation touring Norway and Sweden.

Dr. Wakeman goes to France

Dr. Reginald L. Wakeman, for three years a teaching assistant in the laboratories of Organic Chemistry, sailed for Paris on August 29. He has been awarded the Moore Fellowship and will spend a year studying organic chemistry at the Sorbonne.

AVERY A. ASHDOWN.

The Road to Success

(*Continued from page 181*)

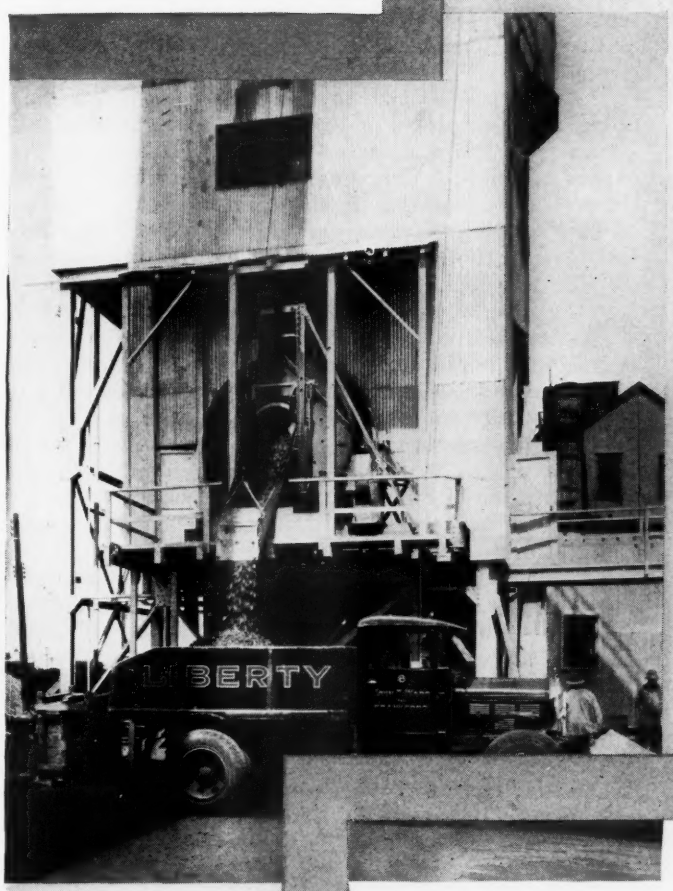
ment. Good judgment will determine how much time should be allocated to each. Determination and will power will help him to adhere to the program once it is established. Accuracy and thoroughness will prevent him from slighting his work or from committing careless blunders. Persistence will overcome the inclination to give up when the practice grows tiresome or discouraging. There can be no better training for his future career than the exercise of these qualities and the discipline which they impose.

Finally, each student is supplied with a complete and ideal laboratory for research in the field of human knowledge in the form of thousands of fellow students with whom he must come in contact. Every type of disposition and temperament will be represented among them. Close observation and study of their behavior, their different characteristics, mannerisms, mental viewpoints and reactions will serve to classify them into distinctive groups, so that similar individuals can be readily identified in the future.

Let the student who would rise to a position of future leadership then, devote himself diligently to acquiring the fundamental knowledge derived from the classroom and thus assure himself of the first 13% of his final equipment but let him also with equal insistence avail himself of the many splendid opportunities to perfect his education along the other and even more important lines of development which go to make up the remaining 87% without which he can never expect to excel in the business and professional world.

Thus will he be placed in the advantageous position in advance of his contemporaries and accelerate his final advancement into the ranks of the nation's great leaders.

Ransome BIG MIXERS for CENTRAL MIXING PLANTS



No. 84-S Ransome Standard Building Mixer in Liberty Corporation's Plant, Philadelphia, Pa.

ABOVE is shown just one of the central mixing plants in the Philadelphia territory equipped with No. 84-S Ransome Standard Building Mixers this year. Others are the Union Paving Company and the Camden Lime Company.

Ransome big mixers are *real* tools for central mixing plants because they insure *thorough* mixing and *fast* discharge. Their low overhead room makes them space savers. Their low upkeep, due to high grade materials, simple design and the dependable Ransome service, makes them money savers.

That's why so many central mixing plants are equipped with Ransome big mixers.

Write for Bulletin 122. It tells the Ransome Big Mixer story.

Ransome Concrete Machinery Company

1850 — Service for 80 Years — 1930

Dunellen New Jersey

Reflections of an Engineering Experience

(*Continued from page 178*)

in which a chemist is as properly dressed as the surgeon in his white hospital clothes. But neither field nor laboratory justify the engineer in coming to the office or to a convention inappropriately dressed. We always feel on better terms with ourselves when we're well groomed — in addition to being more acceptable to our fellows.

The same care we have for our clothes applies to our physique — I don't mean soap and water — but our vigorous physical condition. A pallid, lifeless face, a nervous demeanor and inability to sit still or look some one right in the eye while you are talking, are not conditions conducive to confidence from those with whom one is in contact. People are apt to assume that this state, with slouchiness, may extend to the mental equipment. This means proper care of the body — which again means proper exercise — not intensive athletics — and proper and adequate rest. And please remember that weariness and fatigue are not overcome by quantities of food, but solely by rest — repose and sleep. A tired or overworked man is always an inefficient man in many ways. In the German army this element was considered of such importance that a tired officer was never allowed to participate in any important conference.

These considerations of personal and physical appearance were forcibly brought to my attention during the recent annual convention of the American Society of Civil Engineers at New York City, as was also that of the mental attitudes of many of the engineers in attendance. They complained that they were not getting ahead; were not getting what they thought they should have of the products of their brains. Generally this is their own fault and due to their lack of self-confidence and lack of initiative, both serious handicaps and the main causes of failures. Comparatively few spic-and-span or radiantly healthy-looking men were to be seen and many had various complaints about their health. They said they did not have time to exercise or keep themselves in good physical condition.

I watched them eat and ceased to wonder at their appearances after observing the amounts and varieties of foods they took at one meal, mixing things which would only produce fermentation, indigestion, toxaemia. Their physiological economics were certainly taxed to the breaking point. They didn't seem to realize the resulting physiological strains and enormous bodily work required to digest large quantities of food, or the resulting poisons in body and brain. In New York City there is frequently considerable business done during the lunch hour, but generally little or nothing is done after a heavy business lunch. It may interest you to know, too, that a recent questionnaire sent out by the American Society of Civil Engineers brought many replies stating that the writers had given up smoking as they had found that it decreased their mental efficiency.

Exercise is constantly needed to avoid atrophy. This is clearly understood in the case of our muscles and general physiological state. It is not less true in the case of our minds. Orient and coördinate whatever you learn — leave nothing in the form of isolated facts. Always be a real scientist and develop a clear organization of your thoughts, so that you can readily marshal all the facts bearing upon any problem. Constantly test the logic of your thinking processes.

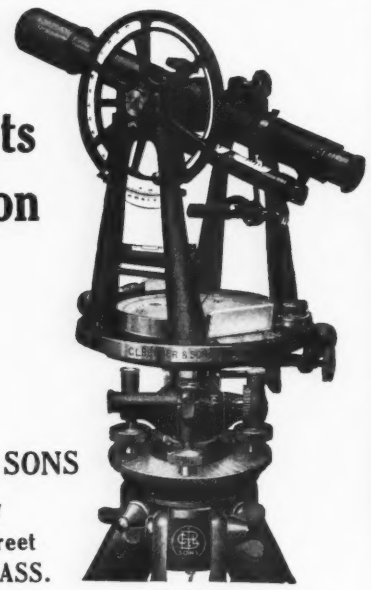
A chief task of the engineer is to acquire useful knowledge along definite lines, and for this end he must learn how to remember selectively; it is equally important to know how to forget selectively. The recognized symbol of every successful engineer is an orderly mind. Each of us has to settle down to do something, not everything or anything. The fellow who tries to do everything, or learn everything, or remember everything, usually does nothing.

When you leave this great institution you are only beginning to learn. Here you are grounded in certain rudiments and principles and taught how to think, and thereby started out with an immense initial advantage. But you should never cease learning if you would have any standing in your profession. He who fails to learn continually, will retrograde. In other words, when a man says he "Is," he is generally finished; because a real life is a constant "Becoming," and never a "Being."

Frequently some fellow bursts forth in the newspapers as a self-declared, self-made man, and one who only learns from his *own* experience. Investigation generally reveals such men as mediocrities, for it is absolutely impossible to advance very far by just one's own experiences. It is the knowledge of and application

(*Continued on page 200*)

Standard Instruments of Precision



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Incorporated
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BOSTON 19, MASS.

Fires and Engineering

(*Continued from page 185*)

tion and see that established fire protection principles are uniformly observed.

The full application of known principles of fire protection engineering to the reduction of the annual fire loss in the United States of $500,000,000 has been prevented by the notion that fires are solely a problem of insurance companies. The average individual seldom reasons far enough to see that the insurance companies must collect in premiums enough to cover whatever is burned, so that instead of being an insurance matter it is very definitely the concern of every citizen. This situation promotes indifference to fire in quarters where, were it not for insurance, the seriousness of the fire problem would be brought immediately home to the individual.

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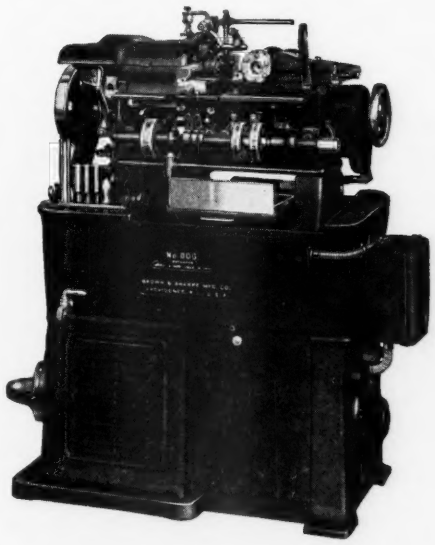
Parts from steel as well as brass, aluminum and other freely cut metals can be economically produced with a high degree of accuracy.

Many of the features of this machine are entirely new, the results of long study and experimental work by Brown & Sharpe Engineers.

We are always glad to send a catalog of our complete line, or literature describing any of the machines of our manufacture.



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BROWN & SHARPE MFG. CO. PROVIDENCE, R. I.

Sectional view, Fig. 106, Jenkins Standard Bronze Globe Valve, screwed.

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In the long grind, it's the athlete with the stamina who lasts.

So, too, with a Jenkins Valve. It's the body stamina that counts, that keeps the valve in the line, unaffected by the strains of pipe weight and settling, lifting, expansion, contraction or frequent operation.

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Jenkins
VALVES
Since 1864

Reflections of an Engineering Experience

(*Continued from page 198*)

of the experience of others by which we advance and develop new ideas, by combining them with our own. An individual life is far too short to do much with only its own experience.

As engineering and scientific experience is constantly becoming more advanced and complex, there follows the necessity of ever and eternally keeping at it by studying and "Becoming." You will appreciate this when you apply for membership in any of the great engineering societies such as the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers. The standards of all are now very high, and your professional standing will require that you be members of one or more of these societies.

Engineering is a highly technical profession and one requiring a high degree of technical and lay culture for success; but side by side with the technical training a most valuable asset is "Common sense." The most successful engineers are those who combine the greatest amount of common sense with the proper technical knowledge, order and system. But above all, let your common denominator always be common sense.

Develop Inhibitions: Body and mind are normally restless and desire more change of occupation than serious work permits. The mind wants to digress from the subject of study; the tongue wants the pleasant exercise of talking; the muscles want to rise and stretch. The will inhibits their natural tendencies and forbids mind or body to leave the task. Learn to say "No" both to *yourself* and to *others*. Acquire the ability to force the mind to continued effort. Lay out and plan your work carefully and keep your desk clean. When you quit for the day leave a clear desk and have a definite point of commencement for the next day.

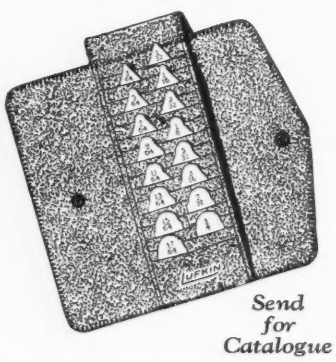
The idea of needed Inhibitions goes out beyond our work and studies into the social conduct of life. Only the weak and undisciplined try to throw off the decorous restraints of society. This is attempted under a hundred titles such as "Modernism," "Self-expression," "Free Thought," "New Freedom," "Overcoming a Suppressing Complex." All these are camouflages — Intellectual Cosmetics. Successful men are modern, free, and self-expressive to a degree undreamed by those who indulge in vacuous excuses. But the successful man faithfully builds up his powers of inhibition — as a key to sustained, effective effort, and to the true freedom which is found in perfect adjustment to society.

To the list of "Cosmetics" might be added Temperament, which, analyzed, always proves to be an attempted justification for an act of rudeness, of inconsideration, or injustice to someone else. As the word is commonly used, it is an excuse for deliberate release from inhibitions, especially exemplified at times in the bad manners of some artists — and of not a few who have not the compensatory virtue of artistry. Frequently attempts are made to found these releases from inhibitions on so-called Socialism. Well, a modern Socialist is often one who is actuated by a fervent desire to divide up somebody else's material possessions — a desire which vanishes as soon as the Socialist acquires some himself. If you want to do anything rotten and feel that you can justify it to yourself, go ahead and do it and then take the censure or punishment due like a man. But don't try to justify your release from inhibitions by any of the intellectual cosmetics above quoted.

Learn to cultivate Tolerance of the ideas, suggestions, and opinions of others. Hear them patiently, and answer courteously and gently — especially if your answer must oppose. The day of controversies between scientists is past and in its place has come what Nicholas Murray Butler has called "Intellectual Charity." That oft-defined, much-misunderstood commodity — Tact — consists in tolerance and amiability in our contacts with others. A man whom you've needlessly made sore can hurt you needlessly in the opinion of others. And on your side, don't harbor hate or envy. They are serious psychological and physiological disturbers as well as being frequently a practical acknowledgment of inferiority. And above all, keep a record of unassailable integrity.

I have no right to use the word "snob" within Technology's halls — the word is yours by squatter sovereignty. You have preëmpted it. But may I plead that there are snobs and Snobs? There is an intellectual pride that knows the supreme value of ability, it knows that all the good of this world is brought about by intelligence. Without inventive and administrative intellects, this imperfect human world would have remained in its imperfection — at any stage of its development at which invention ceased to spy out improvements, or administrative energy ceased to apply them effectively to the improvements of everyday life. Such intellectual pride rejects the idea that equal improvements can be brought about by the less intelligent; and the retort of Demos is to cry "Intellectual Snob." This is the noble snobbery of those who face the truth; and is not to be classed with false pride in place or money.

(*Continued on page 202*)



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THE LUFKIN RULE CO. SAGINAW, MICHIGAN

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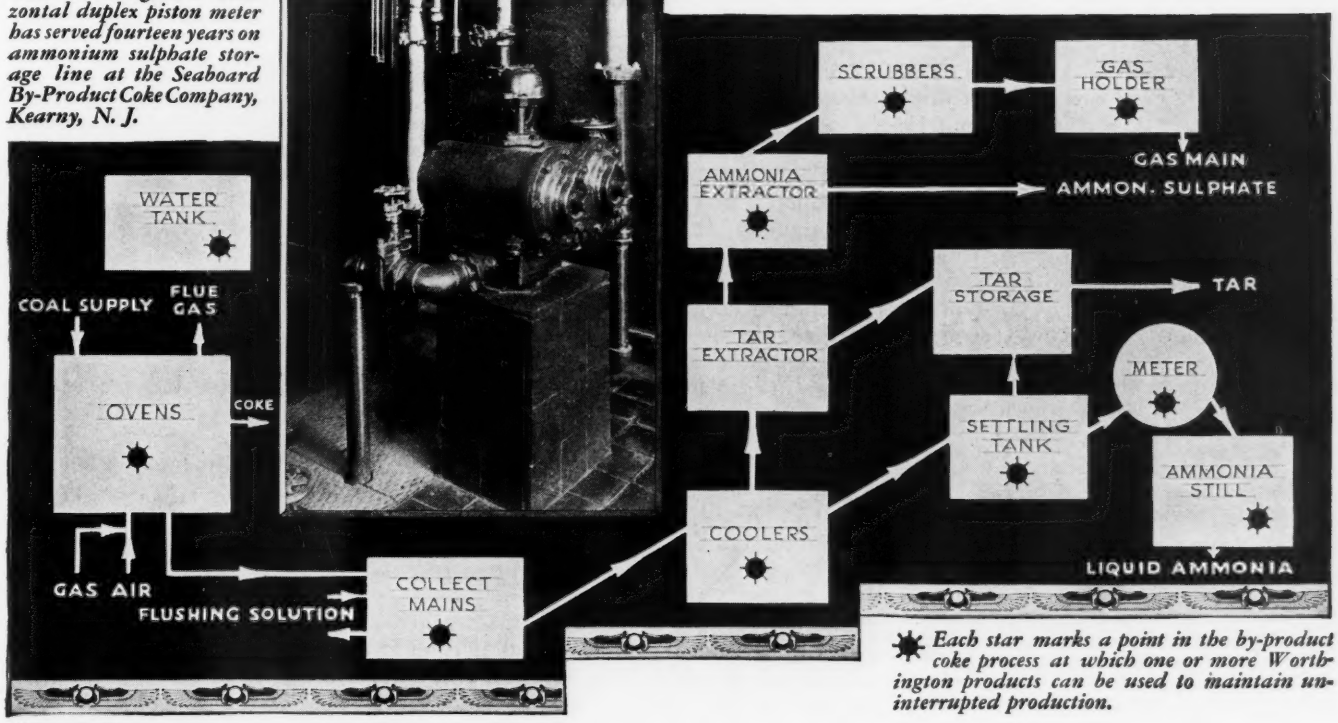
This Worthington 2" horizontal duplex piston meter has served fourteen years on ammonium sulphate storage line at the Seaboard By-Product Coke Company, Kearny, N. J.



Each star marks a point in the by-product coke process at which one or more Worthington products can be used to maintain uninterrupted production.

They bought *today's* performance . . . *fourteen years ago*

IN 1916, the Seaboard By-Product Coke Company installed this Worthington horizontal duplex piston meter for measuring the passage of ammonium sulphate from settling tank to still.

Today, the meter is still in service, playing an important part in safeguarding production efficiencies. It measures 37½ tons of liquid per day.

This service record is a typical one . . . for Worthington's seventy years of experience in building meters is reflected, in each unit produced, in the ability to function accurately year after year with a minimum of maintenance.

The importance of measuring the fluids involved in industrial processes is sometimes overlooked. A check-up of your liquid handling problems by a Worthington engineer may show you a means of cutting costs.

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Reflections of an Engineering Experience

(*Continued from page 200*)

The three outstanding classes of certain branches of engineering are Consulting, Constructing, and Operating. All are important, but practically all of the real problems and thrills come within the experience of the great constructing engineers. In fact a good consulting engineer must first have matriculated as a constructing engineer, and so also must the operating engineer. It is not very difficult to prepare a fine set of plans or drawings for a proposed subway, bridge, dam, or tunnel; but in the execution of the plans is generally where the real skill and ability are needed, and where the fitness and skill of the constructing engineer enter. In fact, the constructing engineer frequently has to advise serious changes in the plans. Don't ever get so that you can't learn from others.

Make no small plans. Get used to thinking, planning, and building in a large way. You will find it far easier than doing so in a small way. Don't be afraid. It is generally easier to finance a five-million-dollar proposal than it is to finance one of fifty thousand dollars. Make sure of yourself and of what you are doing and then don't be afraid to fight it out.

In many instances my proposals were branded as visionary and too expensive, but each case has more than justified itself and confuted its opponents. For example, some years ago I conceived the idea of a railway between New York City and the state line at Port Chester, New York. As speed was the paramount consideration, I proposed that no grade crossings be used; though the cost would be very much higher, the estimates of the probable earnings showed that it would pay. Nothing is ever too expensive that will pay or earn a fair return on the amount of money invested. I had been waiting for an opportunity of this kind. This led to the New York, Westchester and Boston Railroad, which I originated under the name of the New York and Portchester Railroad. It included about twenty-five miles of roadway, involving a total cost of over twenty-five million dollars. It has two express and two local tracks. The road was twenty-five years ahead of its time when it was planned and put in operation, and today, so far as I know, there is nothing quite like it in this country. But the road has been running for some years now and is paying. It is on this railroad that the pioneer high-speed work was done.

The project was fiercely attacked. Experts proved that it would not pay. Powerful railroads, trolley lines, and large financial interests fought against it, in the courts and over conference tables. It was a fight every step of the way. I started the New York and Portchester Railroad in 1903. It took me six years to get it by the Railroad Commission and through the courts, including the franchises in New York City and all the towns northward along the line. They had me (according to their constantly circulated reports and, I really believe, their own ideas) beaten, down and out, dead and buried a number of times. They knew it and were sure of it.

But *I* never knew it. Every cent I had in the world or that I could borrow was in that preliminary work. If they had beaten me, it might have utterly ruined me, but — I never thought of such a thing as being beaten; had too many other things to think about and do; working eighteen hours a day planning and designing, addressing railroad commissions, common councils, and boards of aldermen. It was a stand-up and knock-down fight for six years from the sound of the bell, which was the first application to the Railroad Commission in 1903.

The front pages of the newspapers heralded the battle, and part of my work was to meet the editors and keep them fully informed; for in any large struggle the public has a right to the facts, and a good cause may be lost through a lack of clear public explanation — which can best be had in the newspapers. I had never sought publicity, but now it sought me. An essential part of the fight was to keep a frank engineer's account of the facts and arguments before the people whom the new railroad hoped to serve. Fighting is seldom lonely — there are comrades in arms as well as enemies; people whom I had never heard of wrote and telegraphed me not to give up; editors of the greater newspapers lined up with me; and the sister of New York State's Governor sent me a beautifully bound book called "The Value of Courage," edited by Franklin Lawrence Knowles, with a brief, splendid letter which I still like to quote.

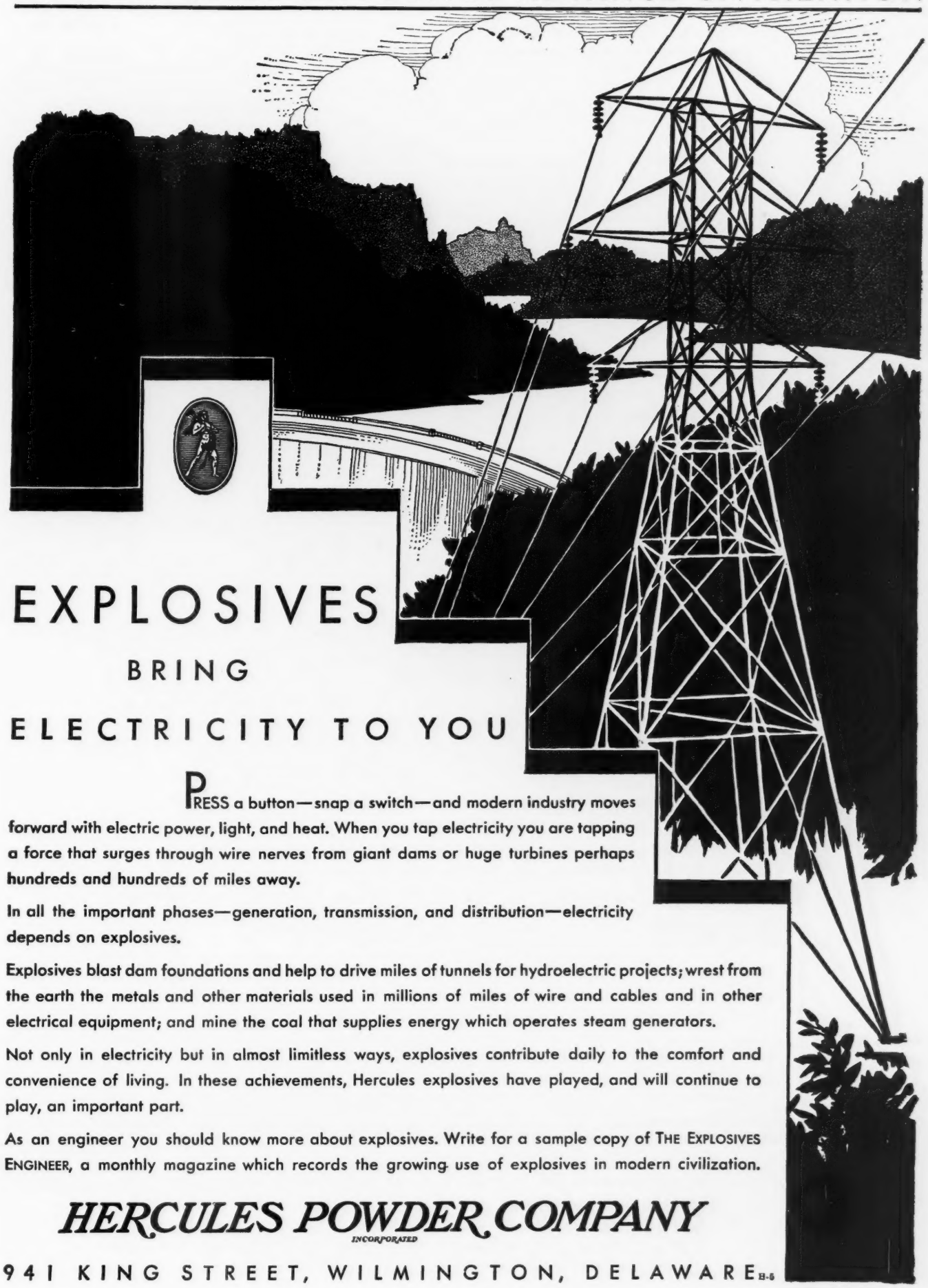
We all need allies in battle, and this encouragement seemed to gird me with an impenetrable armor; I felt I had it all over Achilles, for he had one weak spot. On the other hand, while it is well to make extensive plans, it is always well not to develop disdain for what may appear to be of no value. When Faraday first showed the Royal Society his experiment of moving a closed electrical circuit, containing a galvanometer, across a

(*Continued on page 204*)

The Hudson River Bridge

"It is largely because of our increasing knowledge of Physics that each year the engineer dares more greatly in construction, performing feats which were thought beyond the bounds of possibility a short time before."—Major Gotshall

HOW HERCULES EXPLOSIVES ADVANCE CIVILIZATION



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941 KING STREET, WILMINGTON, DELAWARE H-5

Reflections of an Engineering Experience

(*Continued from page 202*)

magnetic field, somebody asked him: "But what's the use of this toy?" Faraday replied: "What's the use of a baby?" Faraday's electromagnetic baby has grown up and founded the aristocratic family of Dynamo-Motor. And science's babies grow to be civilization's giants far faster today than they did in Michael Faraday's time.

Now as to the matter of reaping the fruits of one's abilities. The engineer is the pivot about which revolves almost every great industrial activity. He frequently has the idea or sees the opportunity; he investigates and plans it, and when he concludes that it will be a paying affair, he meekly hunts up some promoter and hands it over to him. The promoter, who must get the facts and arguments from the engineer, often reaps the chief material profits and honors, while the engineer may hold some precarious job and obscure place in the background.

Why does he hunt the promoter? Usually because he lacks confidence in himself and fears that he would not get the necessary money himself, or has not the nerve to risk a little himself. The engineer's command of money would often be far greater than that of the promoter if he would only develop self-confidence and the easily acquired ability to present his plans and arguments himself.

Money is always seeking an outlet and an investment and only requires confidence to flow freely. Years ago this fact was recognized by a number of alert, thinking engineers, with the results that we now have such remarkable organizations as Stone and Webster, of Boston; J. G. White and Company and the Coverdale Company, both of New York, and the Byllesby Company, of Chicago.

Thirty years ago we engineers were all beating around in the sawdust together with only a lot of excellent but intangible possessions as our chief assets. We had: (1) Determination, (2) Plenty of energy, (3) The will to learn all there was to learn about our chosen fields of activity, (4) Active faculties of observation, (5) Courage, (6) Common sense, (7) The conviction that we could put our ideas across ourselves better than any substitute, and perhaps some others of the same intangible kind. But most of us needed also knowledge of business methods, the ability to organize a company and to enlist capital. Today all of this has long been in our hands, and the organizing, executive engineer is a familiar figure — and a most welcome one.

The requisites for the launching of an enterprise today are: (1) Technical knowledge and courage, (2) The fair probability of offering a good investment, and the engineer alone determines that, and (3) The organization of a company — a simple matter involving a certificate of incorporation, a stockbook (easily and cheaply purchased), the issuance of a few shares of qualifying stock, and the use of a little money. Preliminary promotion money can always be obtained by making the risk an object to a few people. However, before taking the second step be sure to have behind you a record of success. With success as your background you will soon be in the position of Emerson's man with the best mouse-trap. No matter where you go the investing public will develop paths to find you.

The securing of the final relatively large amount of money is often the simplest matter of all, as every source of money is always seeking opportunities for its distribution. With a record of success behind you, you may find yourself suffering from what the French call *l'embarras de choix;* in other words, you may have to select from among several as your financial backers. Nobody will work for you for nothing. Don't expect to get advice or assistance of any kind for a "Thank you." When others serve you, compensate them liberally, and then you will be anxiously welcomed back.

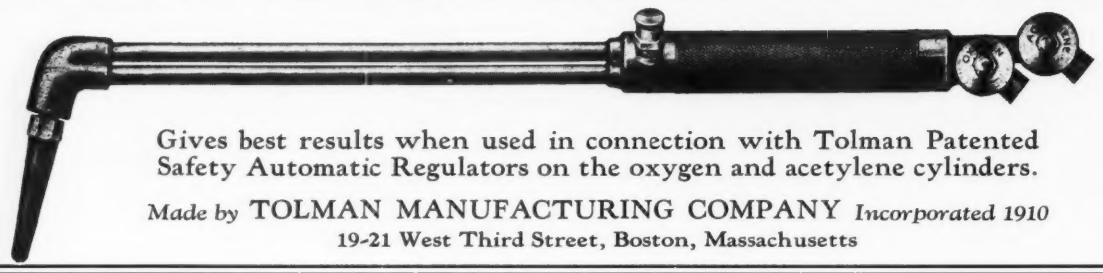
The engineer has at least one great advantage over the research scientist — engineering problems are broader, while research problems are far more specialized. Occasionally we hear it said that the more a man of science knows the less confident he becomes, and we hear the specialist referred to as one who "knows more and more about less and less."

When a man complains that he is always out of luck and can't get a break anywhere, it is almost always a case in which, assuming his general or special competence, he has not had courage. This applies *especially* to the matter of launching new enterprises, although its applicability is general. At the recent American Society of Civil Engineers' convention some half-dozen men told me of the splendid opportunities that had opened before them, but added that they had not felt like risking it. They had saved up so and so; they had fairly good jobs; they had home responsibilities — and if things had gone wrong, so and so. In practically each of these instances they related how someone else had developed the idea or proposition and reaped handsomely by taking the risk. Good jobs, with relatively light responsibilities and a consequent cumulative indisposition to take a chance or suffer some temporary inconveniences, develop an immense amount of inertia and are very often the cause of men falling into ruts and remaining there.

Read the lives of some of the great pioneer railroad builders. I know two of the greatest who said that often they did not know a week ahead where the next payroll for their men was coming from during the times they first launched their enterprises. These were courageous men with open minds, great capacity for work,

(*Continued on page 206*)

TOLMAN WELDING AND CUTTING TORCH



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19-21 West Third Street, Boston, Massachusetts

GOAL!

FOURTH down! Seconds to play! Defending a slender one-point margin of victory, eleven husky bodies have valiantly repulsed three smashing attacks which have advanced the ball a scant foot to the fifteen-yard line. With success almost certainly within the defenders' grasp, the field goal specialist drops far back behind his stalwart line. A crashing impact — a blur of rushing bodies — and his nimble foot sends the ball spinning high between the goal posts for the winning points!

Shift this scene to a battle ground of modern business. The goal is an important contract . . . a substantial order for electrical equipment or appliances. Salesmanship, backed by a product of established quality, plays its important part; but a Westinghouse representative is more than a salesman. The background of specialized engineering knowledge that so often enables him to serve his customers as a consultant in electrification, is what supplies the necessary "punch" to win.

To many a younger college man with Westinghouse has come the opportunity to apply his talent toward the conclusion of a worthwhile transaction. The young men whose photographs appear on this page are but a few of many who, with college only a few years behind them, are finding success with an organization offering such a variety of opportunities in the world's electrical work.

• • •

Below are listed a few of the many important jobs handled by Westinghouse in recent years, wherein younger college men have played important parts:

Lighting of the Barcelona Exposition, Barcelona, Spain . . . Hydro-Electric Generators, Conowingo Station, Philadelphia Electric Company . . . Plant Electrification, Maine Seaboard Paper Co.

Westinghouse

H. B. VIDAL,
Central Station Sales, Niagara Falls, N.Y. University of Colorado, '22

H. J. KONGABLE,
Industrial Sales, Tulsa, Oklahoma, Okla. A. & M., '27

J. A. BUTTS,
Headquarters Sales, University of Maryland, '22

F. H. STOHR,
Headquarters Sales, Univ. of Iowa '22

Engineering Experience

(*Continued from page 204*)

and with successful records behind them. They were called geniuses, but genius is really nothing but the capacity for hard work and the doing of it.

Such men make friends and inspire confidence, and here also note the value of amiability and friends. Without friends we cannot get very far materially, intellectually, or spiritually, for we are constantly in need of friendly contacts to keep up with the world, and to keep our faculties in condition to cope with those of our fellows. On the other hand, it is well to be careful not to dull the mind by contacts with every new-found acquaintance. Select your associates and friends carefully.

Recently I ran across this apt quotation attributed to Gracian (1601–58):

"None is so perfect that he does not need at times the advice of others. He is an incorrigible ass who will never listen to anyone. Even the most surpassing intellect should find a place for friendly counsel. Sovereignty itself must learn to lean. There are some that are incorrigible simply because they are inaccessible; they fall to ruin because none dares to extricate them. The highest should have the door open to friendship; it may prove the gate to help. A friend must be free to advise, even to upbraid, without feeling embarrassed. Our satisfaction in him and our trust in his steadfast faith give him that power.

"One need not pay respect or give credit to everyone, but in the innermost of his precaution man has a true mirror of a confidant to whom he owes the correction of his errors, and has to thank for it." There is a whole volume in those two paragraphs.

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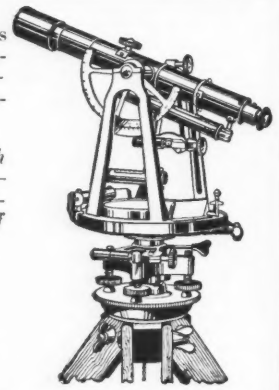

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Recent Books

(*Continued from page 192*)

electrons, those building stones from which nebulae and thence new universes are being formed.

In the rear of the book is a helpful index, and a good list of reference books is included for those wishing to go more deeply into any phase of the subject.

A. B. B.

SCIENCE AND THE NEW CIVILIZATION. *By* PROF. ROBERT A. MILLIKAN, *Norman Bridge Laboratory of Physics, California Institute of Technology. Charles Scribner's Sons, New York. 194 pages, no illustrations. Price $2.00.*

Prof. Robert A. Millikan the physicist, known as the discoverer of cosmic rays; as winner of the Nobel Prize in Physics for his work in isolating and measuring the electrical charge of the electron in 1923, and now director of the Norman Bridge Laboratory of Physics of the California Institute of Technology, has presented in this volume a series of addresses and articles on the relations and responsibilities of science to our present-day civilization and the future of the race. He points out that the scientific age has just started, and that in the millions, perhaps billions of years to come, man can perfect for himself a higher and better type of civilization than has ever existed before, setting forth some of his ideas as to the things which must be done to accomplish this.

One of his most interesting chapters is called "Alleged Sins of Science." Science has often been blamed for the great slaughter of modern warfare, and it has been frequently predicted that man's increasing knowledge will eventually be the means of his own destruction. But Millikan does not blame science for war, nor for the weapons it employs, and he believes that increasing knowledge will diminish rather than increase warfare, for man will have more and greater interests to take up his time. The cave man's sole occupations were probably war and the chase and the making of weapons for these purposes, but as he learned more about his surroundings, and discovered other occupations and interests, these became less important. Dynamite, one of the products of science, it is true is used in war, but it also serves many peaceful purposes. Millikan asks if we would prefer to return to the stone age, because the cave man had no dynamite.

Another chapter is devoted to the subject of available energy. In it Millikan attacks the popular idea that there is atomic energy which will some day be released to do the work of the world, or to destroy it, saying that the great majority of the elements are in a state of maximum stability at the present time, and therefore have no energy to give up by a disintegrating process. These can only be broken apart by putting work into them, instead of taking it out. Man will probably learn to break them down, but he will do it "by the sweat of his brow."

Professor Millikan is well known for his belief that there is no valid quarrel between science and religion. In his chapter entitled "Three Great Elements in Human Progress" some of his thoughts on this subject are set forth. They will be of interest to any reader who has been following the recent debates about science and religion.

The entire volume, which contains eight articles, forms a noteworthy collection of Millikan's thought, and cannot but be of interest to those who are followers of the scientific viewpoint.

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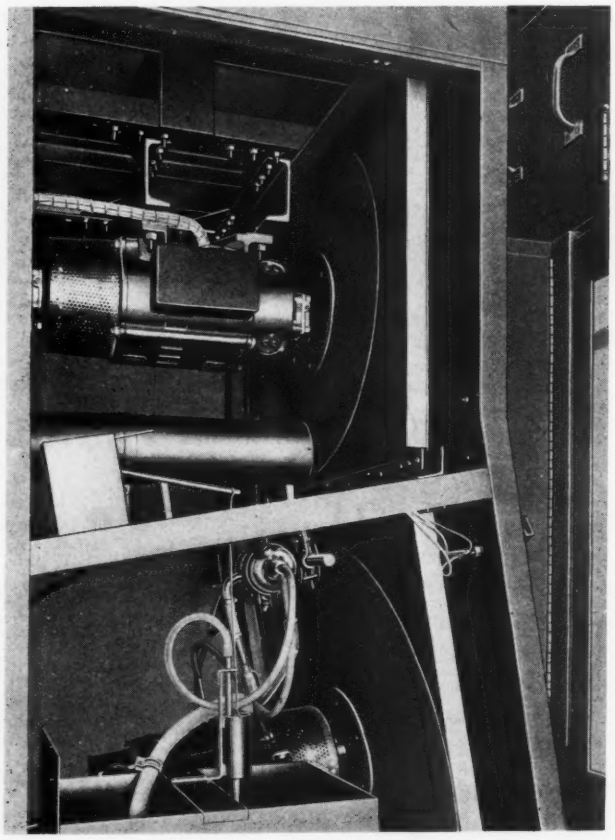
Two-Way Television

(*Continued from page 180*)

image in the most advantageous position for picking up the voice. The loudspeaker, of the moving coil type, is also small; being placed near the image, it gives rise to the illusion of the image actually talking.

In this arrangement of acoustical devices, in which microphone and loudspeaker are close to each other at each end, the microphone is unable to distinguish between the voice from the party in the booth and the voice from the loudspeaker. Consequently, unless precautions are taken any noise will be thrown back and forth between the microphones and the condition known as "singing" results. It is, of course, impossible to talk over the system while it is singing. The walls of the booth have to be carefully sound-proofed, so that as much noise as possible is prevented from being reflected from speaker to microphone. The positions of these instruments must be chosen with the end in view of eliminating undesirable reflections. Such is the loss of sound intensity that it seems as if the speaker were about ten feet away. This impression is in keeping with the size of the image.



Side view of a portion of the opened television cabinets.

Hydrogenation

(*Continued from page 179*)

duced came from the Pennsylvania field. They were low in sulfur and produced on distillation as much as 50 per cent gasoline and kerosene. The residue after removal of the gas oil for which there was a good market was used in the manufacture of lubricants. Today many of the crudes available yield no more than 15 per cent of light products leaving as a residue 85 per cent of heavy black asphaltic oil useful for little except fuel. Furthermore, some of the crudes now used, although yielding reasonably high percentages of light products, contain such high percentages of sulfur that the products produced require expensive chemical treatment before they can be marketed.

The oil industry would indeed be in a bad position were it not for the cracking processes which have increased the percentage of total gasoline obtained from crudes in spite of the decrease in crude quality. But even the best cracking processes cannot convert entirely the materials which they handle. They always produce a residual of coke, and usually a heavy tar. The coke formation makes it necessary for the plant to shut down periodically for cleaning. Furthermore, they are limited in the type of charging stock which they can handle. The heavy residues having the least value which it would be most desirable to convert are the most difficult, and in some cases, impossible to handle. With the Hydro process the conversion of these residues to gasoline is complete. Coke and tar formation are eliminated, gas formation is reduced, and the process is virtually continuous. Thus it will be possible to maintain the proper balance between the production of gasoline and fuel oil regardless of the crude available. This in itself, irrespective of any other advantages, is sufficient to arouse the interest of the petroleum industry. Added to this, the ability of the process to produce low sulfur distillates from high sulfur crudes, and the possibility of modifying the chemical characteristics to yield other products — a field as yet unexplored — it does not seem unlikely that the Hydro process will emerge as a major factor in controlling the future course of the petroleum industry.

Shooting Holes in a Well Casing with a specially constructed gun increased the yield of a water well in Cape Town sixfold. The well was drilled to a depth of 200 feet, but most of the water was found between 65 and 100 feet. However, as a yield of only 286 gallons per hour was obtained, the engineers decided that the casing had been driven beyond the water-bearing strata, and attempted to pull it out, but unsuccessfully. Blasting the bottom of the six-inch casing with dynamite was considered too risky, so a mechanic made an ingenious gun only 5¾ inches long which was used to shoot holes in the side of the casing. The resulting output reached 1,600 gallons per hour!

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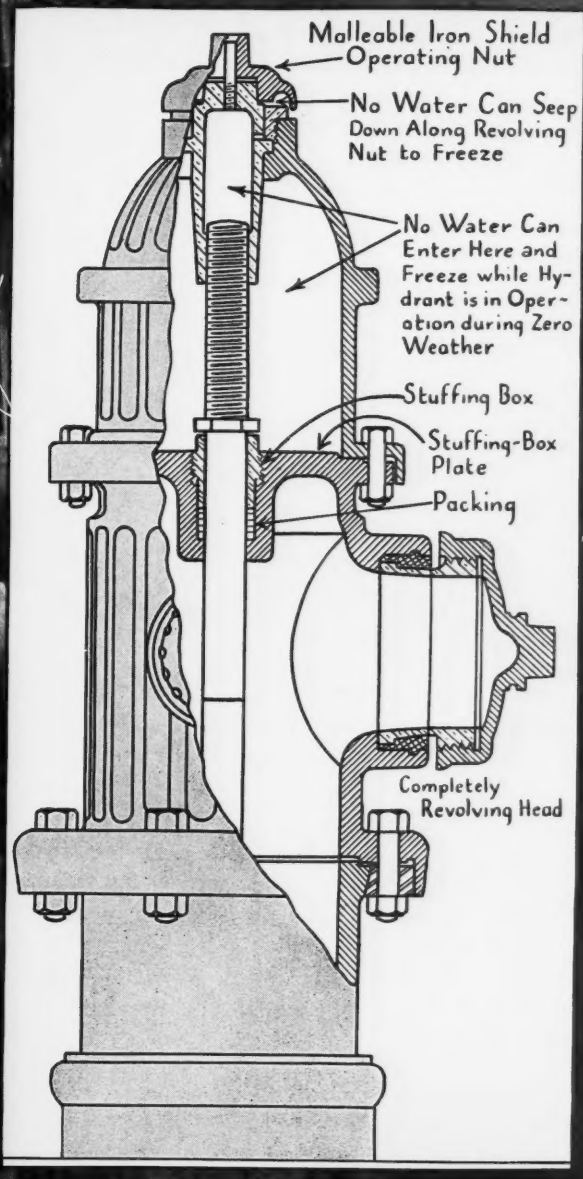
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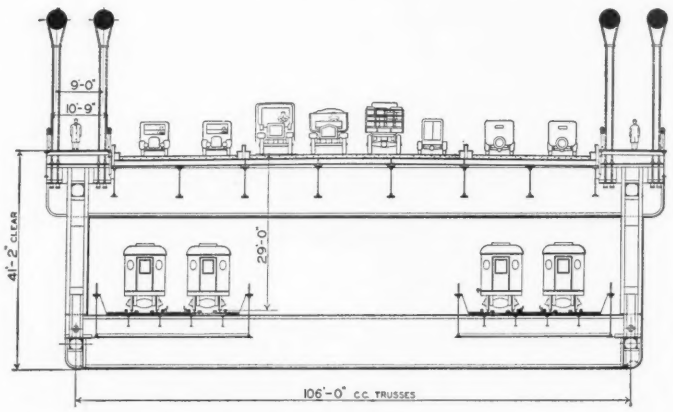
Construction Features of the Hudson River Bridge

(*Continued from page 183*)

The method of placing this great amount of wire is not essentially different from that used in the Brooklyn Bridge, but many improvements have been devised on various structures since that date so that the rate of spinning is now many times faster than it was in the early days. The method is as follows: continuous tramway ropes are hung throughout the length of the cable, one for each of the four. On each tramway rope are attached two spinning wheels or large traveling sheaves, so that while one wheel is at one anchorage, the other is at the other. The wheels are then shuttled back and forth on the tramway, each wheel carrying with it as it travels a loop of cable wire. This loop is elongated as the wheel progresses, so that when it reaches the opposite anchorage, it has drawn with it two wires. The loop is slipped over a strand shoe attached to the eyebars at the anchorage, the wheel picks up another loop from the reels at that side, and proceeds back to the opposite shore. Two wheels in operation on each cable makes possible the spinning of sixteen strands simultaneously. In order to obtain the highest efficiency, positive coördination between all spinning units was essential, and a comprehensive electric signal and telephone system was installed for this purpose. Special reeling machines, capable of being braked, fed wire to the spinning sheaves under the control of an operator in contact with all other phases of the work. As a result, the spinning of the four cables, the last major operation to be completed to date, was finished in the record time of less than ten months, early in August 1930. After spinning, each cable was compacted by hydraulic jacks to a diameter of 36 inches, bound with wire, and given a protective coat of paint.

The span is now (September 1930) nearly ready for the suspension of the floor from the cables. The footbridge ropes, already used to support the foot scaffolds, are to be cut and used to support the floor, thus serving a double purpose. The projected floor will provide for eight lines of vehicular traffic, in addition to sidewalks for pedestrians. Provision has been made in the design for the erection of a second level below that of the first for use by railway and bus traffic.

The problem of distributing traffic to and from the bridge to the main traffic lines is a very important one. Much study has been put into the design of suitable approaches. Conditions on Manhattan Island call for a complicated system of ramps so that connection with Riverside Drive, Fort Washington Avenue, and Broadway can be made without confusion of traffic lines. All



grade crossings and intersections of traffic flow will be eliminated. On the New Jersey shore, the approach is of simpler design, due to the unpopulated condition of the district and to the height of the Palisades. The State of New Jersey is planning an elaborate system of highways which will feed the bridge as efficiently as possible.

The bridge is to be opened to traffic, according to plans of the Port Authority, early in 1932. The initial capacity of the bridge will consist of two foot walks, and two 22-foot roadways at either side of the floor, a central road, forty feet wide, to be constructed later. The towers, at present merely steel skeletons, will eventually be encased in granite, at considerable cost, in order to improve the architectural beauty of the structure. The entire design has been planned for greatest efficiency consistent with cost and with the character of the surrounding territory, so that the structure may have a dignity that will enhance, rather than mar the landscape.

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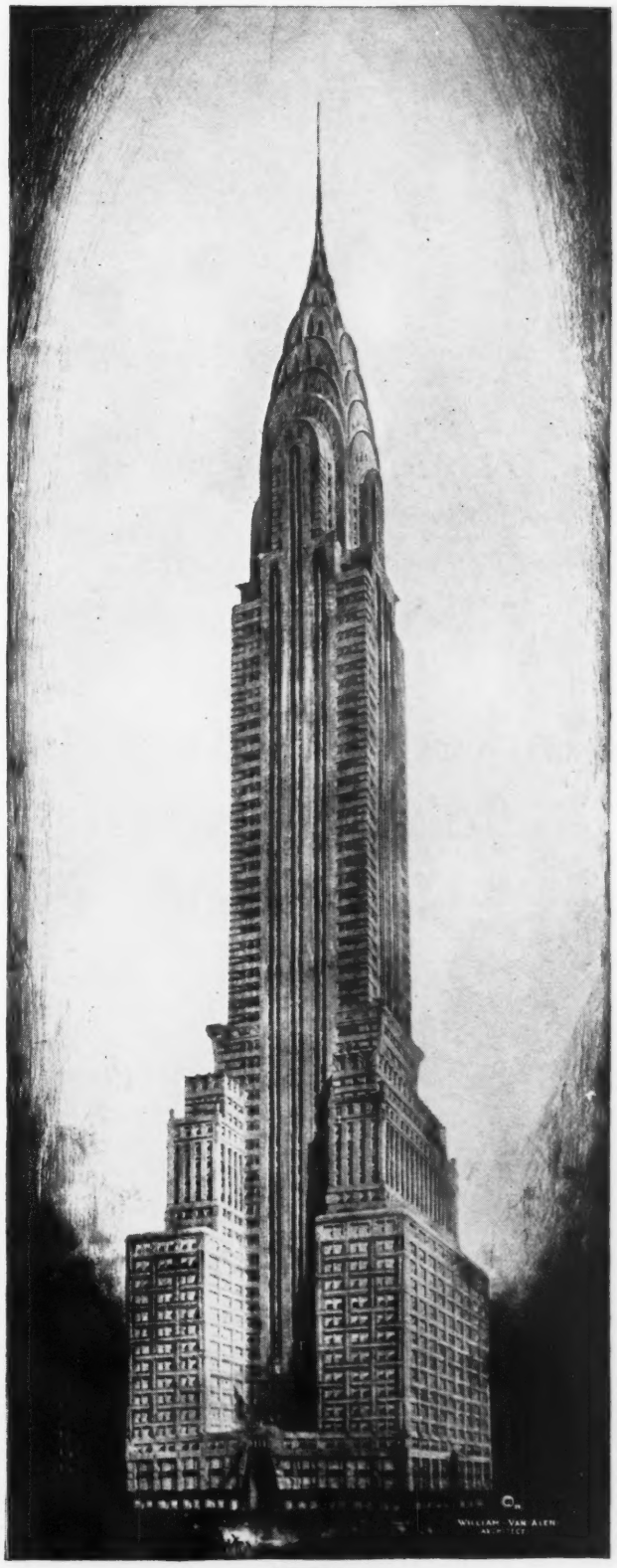

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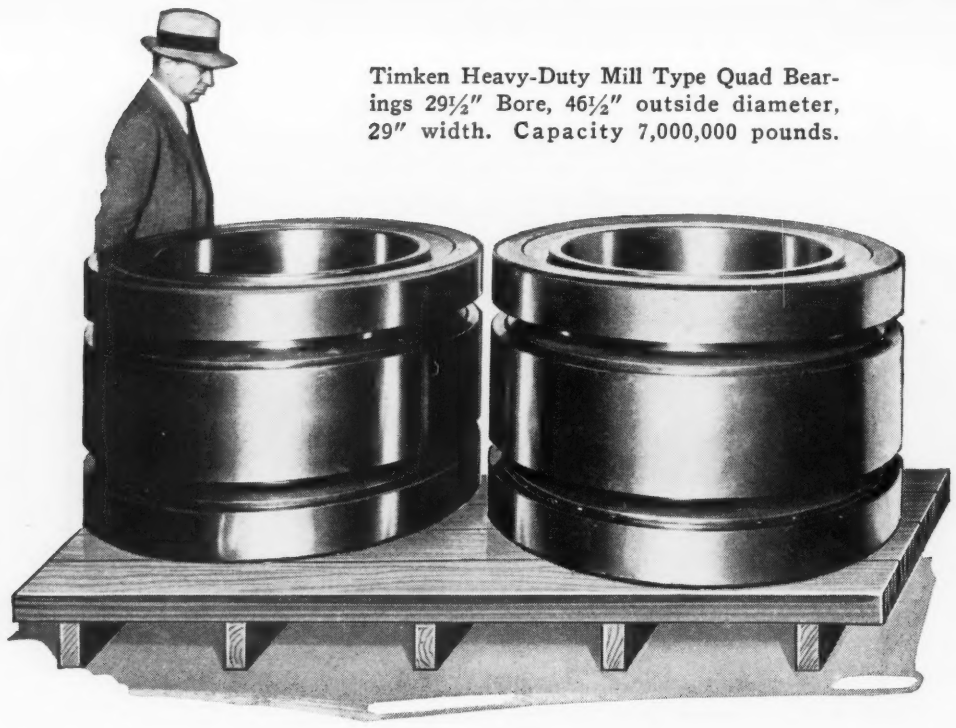

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